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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
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INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭl'o
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mī'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'co
10^{-15}	femto	f	fĕm'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.39 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 4, April 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service
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Technical Notes

Disposal of Radioactive Wastes From U.S. Naval Nuclear-Powered Ships and Their Support Facilities, 1967

M. E. Miles and *J. J. Mangeno*[1]

This report summarizes data on disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities and summarizes results of environmental monitoring performed to confirm the adequacy of waste disposal limits and procedures. The waste disposal data show that the total long-lived radioactivity in liquid waste discharges associated with operation and maintenance of Naval nuclear-powered ships totaled 0.39 curies in 1966 and 0.11 curies in 1967 for all harbors, which is less than the average of 4 curies reported discharged per year during the preceding 5 years. Results of environmental surveys of harbor water and bottom sediment for gross radioactivity and for cobalt-60 have shown that, (1) no increase in radioactivity above normal background levels has been detected in harbor water, (2) discharges of liquid wastes from U.S. Naval nuclear-powered ships have not caused a measurable increase over the general background radioactivity of the environment, and (3) low-level cobalt-60 radioactivity is detectable in localized areas of harbor bottom sediment around a few piers at operating bases and shipyards where maintenance and overhaul of Naval nuclear-powered ships have been conducted over a period of several years.

This report confirms that procedures used by the Navy to control discharges of radioactivity from U.S. Naval nuclear-powered ships and their support facilities are effective in protecting the health and safety of the general public.

A detailed description of the means of disposing of radioactive wastes and the sources of these wastes has been presented earlier (*1*). Table 1, which updates information in previous reports (1–2) lists the total amount of long-lived radioactivity discharged as liquid wastes into various harbors during the past 5 years. Solid radioactive materials from ships are transferred to a shipyard or other shore facility for packaging and disposal. For ultimate disposal, solid radioactive wastes are shipped to AEC or State-approved burial sites since shipyards and shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. The total radioactivity and volumes of solid radioactive wastes disposed of from 1963 through 1967 are shown in table 2.

Environmental monitoring survey procedures have been described in a previous report (*1*). A summary of the 1967 surveys for cobalt-60 in bottom sediment of U.S. harbors where U.S. Naval nuclear-powered ships have been regularly based, overhauled or built is presented in table 3.

Once each quarter, a total of at least five water samples is taken at various locations in each harbor in areas where nuclear-powered ships berth and from upstream and downstream locations. These samples are analyzed for gross radioactivity and for cobalt-60. No harbor water sample has shown detectable cobalt-60 radioactivity. No increases in gross radioactivity of harbor water have been detected.

Monitoring for cobalt-60 in harbor bottom sediment is conducted each quarter year by collecting 20 to 100 samples with a 6-inch square sampler. Samples are taken of the top one-half to one inch of sediment in the immediate vicinity of and away from berthing areas used by Naval nuclear-powered ships. These surveys show that the total amount of cobalt-60 observed in bottom sediment near a few piers is small compared to natural radioactivity present in harbors.

Samples from each of these harbors are also checked at least annually by a U.S. Atomic Energy Commission (USAEC) laboratory to ensure that analytical procedures are correct and standardized. In addition, the U.S. Navy co-

[1] Nuclear Power Directorate, Naval Ship Systems Command, Department of the Navy.

Table 1. Radioactive liquid waste discharges to harbors from U.S. Naval nuclear-powered ships and their support facilities for 1963 through 1967[a]

Location[b,c]	1963		1964		1965		1966		1967	
	Thousand gallons	Curies	Thousand gallons	Curies	Thousand gallons	Curies	Thousand gallons	Curies	Thousand gallons	Curies
Portsmouth, N.H; Naval Shipyard	112	0.03	407	0.13	204	0.24	155	0.01	265	0.01
Quincy, Mass; Quincy Division	104	.09		[d]ND		ND		ND		ND
Groton-New London, Conn; Electric Boat Div., State Pier and Submarine base	101	1.69	201	1.93	828	1.29	1,274	.03	606	.01
Newport News, Va; Newport News Shipbuilding	21	.01	965	.24	3,360	1.70	1,581	.06	1,533	.04
Norfolk, Va; Naval Shipyard and base	300	.07	337	.61	1,146	.44	1,051	.03	1,784	.03
Charleston, S.C; Naval Shipyard and base	246	.14	294	.36	717	.67	369	.04	320	.01
Pascagoula, Miss; Ingalls Shipbuilding Corp.		ND		ND		ND		ND		ND
San Diego, Calif; Navy Pier at Ballast Point	34	.25	35	.40	40	.33		ND		ND
Long Beach, Calif; Naval Shipyard and base		ND		ND		ND		ND		ND
Vallejo, Calif; San Francisco Bay Naval Shipyard	65	.55	63	.62	128	.21	270	.19		ND
Bremerton, Wash; Puget Sound Naval Shipyard	1	.02		ND	196	.01		ND		ND
Pearl Harbor, Hawaii; Naval Shipyard and base	594	.92	405	.98	548	.48	654	.03	683	.01
Apra Harbor, Guam		ND		ND	69	.01		ND		ND
Total	1,578	3.77	2,707	5.27	7,236	5.38	5,354	0.39	5,191	0.11

[a] Radioactivity data are reported as if the entire radioactivity consisted of cobalt-60. Volumes are reported prior to dilution.
[b] For all other harbors in the U.S. and the rest of the world the discharge totaled 180,000 gallons containing a radioactivity of 0.013 curies in 1966 and 16,000 gallons containing 0.001 curies in 1967.
[c] New York Shipbuilding Corporation discharged a total of 0.01 curies into the river at Camden, N.J., from 1960 through June 1967 when all work on U.S. Naval nuclear-powered ships was discontinued.
[d] When discharges in a harbor for a year totaled less than 0.005 curies, ND is reported.

Table 2. Radioactive solid waste disposed of by facilities supporting U.S. Naval nuclear-powered ships for 1963 through 1967[a]

Facility	1963		1964		1965		1966		1967	
	Hundred cubic feet	Curies	Hundred cubic feet	Curies	Hundred cubic feet	Curies	Hundred cubic feet	Curies	Hundred cubic feet	Curies
Portsmouth, N.H; Naval Shipyard	15	0.5	80	2.6	150	2.6	194	9.5	300	198.1
Quincy Mass; Electric Boat Division		[b]ND		ND		ND		ND		ND
Groton-New London, Conn.; Electric Boat Div., Tender at State Pier and Submarine base	102	1.1	99	2.3	155	353.0	148	1,092.8	46	17.0
Newport News, Va; Newport News Shipbuilding	8	.3	22	1.8	198	28.0	70	8.9	167	701.9
Norfolk, Va; Naval Shipyard and tender	3	ND	5	.5	33	1.6	43	2.5	108	85.6
Charleston, S.C.: Naval Shipyard and tenders	35	.4	47	1.0	78	111.5	77	5.6	151	52.0
Pascagoula, Miss; Ingalls Shipbuilding Corp.		ND		ND		ND		ND		ND
San Diego, Calif; Tenders at Ballast Point	2	.1	7	7.5	3	ND	6	0.1	7	0.2
Long Beach, Calif; Naval Shipyard and base		ND		ND		ND		ND		ND
Vallejo, Calif. San Francisco Bay Naval Shipyard	35	19.0	9	.3	47	9.4	90	367.0	92	22.8
Bremerton, Wash; Puget Sound Naval Shipyard		ND		ND	4	.1	14	0.5	141	192.8
Pearl Harbor, Hawaii; Naval Shipyard and base	16	.4	13	.7	8	1.4	7	0.3	11	1.0
Total	216	21.8	282	16.7	676	507.6	641	1,487.2	1,023	1,271.4

[a] This table includes waste from tenders and nuclear-powered ships since such waste is transferred to these facilities for disposal.
[b] Where total radioactivity is less than 0.05 curies, ND is reported.

operates with the U.S. Public Health Service (USPHS) surveys in some U.S. harbors. Results reported in table 3 are consistent with these USAEC and USPHS checks.

Twice per year shoreline areas uncovered at low tide are surveyed for radiation levels with sensitive radiation detectors to determine if any radioactivity from bottom sediment washed ashore. All results were in the range of 0.01 to 0.05 millirem per hour, the same as background radiation levels in similar areas. Thus there is no evidence in these ports that radioactivity from sediment is washing ashore.

Throughout the year film badges are posted at locations outside the boundaries of areas where radioactive work is performed. These films showed that radiation exposure to the general public outside these facilities was not above that received from natural background radiation levels.

In addition to the locations listed in table 3, environmental monitoring has been accomplished by the U.S. Navy submarine tenders which serve as operating bases for U.S. Naval nuclear-powered submarines in Rota, Spain, and Holy Loch, Scotland. Results of the surveys in the harbor at Rota, Spain, have not shown detectable

Table 3. Summary of 1967 surveys for cobalt-60 in bottom sediment of U.S. harbors where U.S. Naval nuclear-powered ships have been regularly based, overhauled, or built

Location	Number of samples with cobalt-60 concentration of: [a]			Total bottom area with cobalt-60 over 10 pCi/cm² (km²)	Estimated total cobalt-60 in top layer of sediment [b] (Ci)
	<10 pCi/cm²	10–100 pCi/cm²	> 100 pCi/cm²		
Portsmouth, N.H. Naval Shipyard	176	0	0	0	ND
Quincy, Mass. Quincy Division	42	0	0	0	ND
Groton-New London, Conn. Electric Boat Div., State Pier, and Submarine base	108	237	50	0.3	2.0
Camden, N.J. (final survey) New York Shipbuilding Corp.	34	0	0	0	ND
Newport News, Va. Newport News Shipbuilding	134	13	1	0.004	0.02
Norfolk, Va., Naval Shipyard and base	344	0	0	0	ND
Charleston, S.C., Naval Shipyard and base	380	0	0	0	ND
Pascagoula, Miss., Ingalls Shipbuilding Corp.	80	0	0	0	ND
San Diego, Calif., Navy Pier at Ballast Point	161	10	0	0.01	ND
Long Beach, Calif., Naval Shipyard and base	155	1	0	0	ND
Vallejo, Calif., San Francisco Bay Naval Shipyard	443	0	0	0	ND
Bremerton, Wash., Puget Sound Naval Shipyard	140	0	0	0	ND
Pearl Harbor, Hawaii, Naval Shipyard and base	205	79	4	0.3	0.05
Apra Harbor, Guam	100	0	0	0	ND

[a] Minimum detectable radioactivity is approximately 2 pCi/cm². Results in units of pCi/g are approximately half the value in pCi/cm².

[b] Total is from areas with cobalt-60 over 10 pCi/cm², which were in the immediate vicinity of piers used for berthing nuclear-powered ships. Where total cobalt-60 is less than 0.01 curie, ND is reported. Core samples more than 1-foot deep from several harbors show that total cobalt-60 present may be two to five times than measured in the surface layer.

cobalt-60 in harbor bottom sediment samples. In 1965 in Holy Loch, more cobalt-60 radioactivity than expected was detected in harbor bottom sediment and on shoreline mud flat areas uncovered at low tide. However, there had been no increase of harbor water radioactivity in Holy Loch above normal background levels. Joint U.S. and British assessments of survey results confirmed that radiation levels in the vicinity of the Holy Loch anchorage were far below those which were at all likely to cause an individual to receive radiation exposure approaching limits for members of the general public. Environmental monitoring during 1967 showed radioactivity levels in Holy Loch are steadily declining.

REFERENCES

(1) VAUGHAN, J. W. and M. E. MILES. Disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities, 1965. Radiol Health Data Rep 7:257–262 (May 1966).

(2) MILES, M. E. and J. J. MANGENO. Disposal of radioactive wastes from U.S. Naval nuclear powered ships and their support facilities, 1966. Radiol Health Data Rep 8:699–701 (December 1967).

SECTION I. MILK AND FOOD

Milk Surveillance, December 1968

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long term concentration trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN), sponsored by the Bureau of Radiological Health and the Bureau of Community Environmental Management, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments have also initiated local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations
Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents

Figure 1. Milk sampling networks in the Western Hemisphere reported in *Radiological Health Data and Reports*

of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation expressed in terms of 2 standard deviations for these concentrations are 1.16 ± 0.08 g/liter and 1.51 ± 0.21 g/liter for calcium and potassium, respectively. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined in the literature (*4*).

The most recent study was conducted in the spring of 1967, with 40 laboratories participating in an experiment on milk samples containing known concentrations of strontium-90, iodine-131, and cesium-137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 of these laboratories participated in the experiment.

In the majority of cases, the results for the laboratories fell within the 3-standard deviation limits considered appropriate for the various analyses. Several results were outside the 3-standard deviation limits and the most deviant of these represented biases from the expected values of 20 to 30 percent (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis not only varies among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over the time periods involved and sampling frequency is not critical. For the case of the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation will also reflect whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention

was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision 2-standard deviations
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter
Iodine-131, Cesium-137, Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the United States data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance for the use of Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/yr)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)	Range II (pCi/day)	Range III (pCi/day)
Strontium-89	Bone	1.5	0.5	[b] 2,000	0–200	200–2,000	2,000–20,000
	Bone marrow	.5	.17				
Strontium-90	Bone	1.5	.5	[b] 200	0–20	20–200	200–2,000
	Bone marrow	.5	.17				
Iodine-131	Thyroid	1.5	.5	100	0–10	10–100	100–1,000
Cesium-137[c]	Whole body	.5	.17	3,600	0–360	360–3,600	3,600–36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.
[b] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.
[c] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in a retrospective manner.

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first year total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c] 1,110,000
Strontium-90	Bone marrow			[c] 51,000
Cesium-137	Whole body			[c] 720,000
Iodine-131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.
[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.
[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.
[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered.

Table 3. Concentration of radionuclides in milk for December 1968 and 12-month period, January through December 1968

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	7	8	0(4)	0	18(4)	14
Alaska:	Palmer[c]	P	5	5	0(4)	0	10(4)	13
Ariz:	Phoenix[c]	P	0	1	0(4)	0	0(4)	2
Ark:	Little Rock[c]	P	18	21	0(4)	0	21(4)	19
Calif:	Sacramento[c]	P	0	2	0(4)	0	0(4)	5
	San Francisco[c]	P	3	2	0(4)	0	0(4)	5
	Del Norte	P	20	21	0	0	0	22
	Fresno	P	0	0	0	0	0	5
	Humboldt	P	5	4	0	0	15	13
	Los Angeles	P	0	1	0	0	0	6
	Mendocino	P	3	3	0	0	0	4
	Sacramento	P	3	2	0	0	0	4
	San Diego	P	0	0	0	0	0	3
	Santa Clara	P	0	0	0	0	0	6
	Shasta	P	3	4	0	0	0	4
	Sonoma	P	0	2	0	0	0	4
Colo:	Denver[c]	P	7	5	0(3)	0	0(3)	6
	West	R	(d)		(*)	(*)	(*)	(*)
	Northeast	R	(d)		(*) (2)	1	(*)	(*)
	East	R	(d)		(*)	(*)	(*)	(*)
	Southeast	R	(d)		NS	(*)	NS	(*)
	South Central	R	(d)		NS	(*)	NS	(*)
Conn:	Hartford[c]	P	8	10	0(4)	0	15(4)	12
	Central	P	7	7	4(3)	0	4(3)	10
Del:	Wilmington[c]	P	9	10	0(4)	0	7(4)	8
D.C:	Washington[c]	P	6	9	0(3)	0	11(3)	6
Fla:	Tampa[c]	P	9	8	0(3)	0	58(3)	66
	West	R	7	14	0	3	26	23
	North	R	18	14	0	0	37	25
	Northeast	R	7	8	0	2	36	81
	Central	R	NA	9	0	2	52	85
	Tampa Bay area	R	10	8	0	0	70	71
	Southeast	R	8	9	0	0	81	109
Ga:	Atlanta[c]	P	13	14	0(4)	0	18(4)	20
Hawaii:	Honolulu[c]	P	5	4	0(8)	1	0(8)	3
Idaho:	Idaho Falls[c]	P	4	6	0(8)	0	10(8)	9
Ill:	Chicago[c]	P	10	9	0(5)	0	12(5)	10
Ind:	Indianapolis[c]	P	8	8	0(5)	0	11(5)	7
	Northeast	P	8	11	0	0	15	11
	Southeast	P	12	11	0	0	15	12
	Central	P	15	9	0	0	0	9
	Southwest	P	13	10	0	0	20	13
	Northwest	P	17	10	0	0	15	12
Iowa:	Des Moines[c]	P	5	7	0(3)	0	1(3)	6
	Iowa City	P	6(2)	7	0(2)	0	8(2)	5
	Des Moines	P	4(5)	7	0(5)	0	5(5)	3
	Spencer	P	5	6	0	0	13	4
	Charles City	P	NS		NS		NS	
Kans:	Wichita[c]	P	7	8	0(5)	0	3(5)	4
Ky:	Louisville[c]	P	9	12	0(3)	0	2(3)	6
La:	New Orleans[c]	P	15	20	0	0	21	23
Maine:	Portland[c]	P	14	12	1(5)	1	25(5)	28
Md:	Baltimore[c]	P	9	10	0(5)	0	10(5)	7
Mass:	Boston[c]	P	12	12	0(5)	0	17(5)	24
Mich:	Detroit[c]	P	9	9	0(5)	0	7(5)	11
	Grand Rapids[c]	P	12	11	0(4)	0	18(4)	15
	Bay City	P	NS	4	NS	0	NS	6
	Charlevoix	P	NA	5	(*)	(*)	0	8
	Detroit	P	6	4	(*) (5)	(*)	4(5)	5
	Grand Rapids	P	6(2)	5	(*) (4)	(*)	6(4)	7
	Lansing	P	5(2)	4	(*) (3)	(*)	8(3)	3
	Marquette	P	10	7	(*) (2)	(*)	34(2)	24
	Monroe	P	4	3	8(2)	(*)	0(2)	1
Minn:	Minneapolis[c]	P	10	11	0(7)	0	11(7)	13
	Bemidji	P	17	15	0	0	22	22
	Mankato	P	6	6	0	0	0	0
	Rochester	P	9	9	0	0	13	0
	Duluth	P	16	19	0	0	21	30
	Worthington	P	9	6	0	0	0	0
	Minneapolis	P	14	12	0	0	0	13
	Fergus Falls	P	9	10	0	0	0	0
	Little Falls	P	13	10	0	0	0	14
Miss:	Jackson[c]	P	16	17	0(5)	0	15(5)	15
Mo.:	Kansas City[c]	P	0	7	0(4)	0	5(4)	5
	St. Louis[c]	P	8	9	0(5)	0	4(5)	7
Mont:	Helena[c]	P	6	5	0(8)	0	13(8)	8
Nebr:	Omaha[c]	P	7	7	0(4)	0	5(4)	6
Nev:	Las Vegas[c]	P	0	1	0(8)	0	2(8)	4
N.H:	Manchester[c]	P	9	13	0(5)	0	27(5)	35
N.J:	Trenton[c]	P	10	10	0(3)	0	11(3)	10
N. Mex:	Albuquerque[c]	P	0	2	0(5)	0	5(5)	2

See footnotes at end of table.

Table 3. Concentrations of radionuclides in milk for December 1968 and 12-month period, January through December 1968—Continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES—Continued								
N.Y:	Buffalo[c]	P	6	8	0(4)	0	14(4)	10
	New York City[c]	P	9	12	0(5)	0	16(5)	15
	Syracuse[c]	P	9	9	0(4)	0	12(4)	7
	Albany	P	10(10)	8	0(4)	0	(c) (4)	(c)
	Buffalo	P	NA	7	NA	0	NA	(c)
	Massena	P	11(2)	11	0(2)	0	23(2)	23
	Newburg	P	14(4)	10	0(4)	0	(c) (4)	(c)
	New York City	P	12(4)	12	0(4)	0	16(4)	(c)
	Syracuse	P	11(2)	7	0(2)	0	(c) (2)	(c)
N.C:	Charlotte[c]	P	16	15	0(4)	1	13(4)	12
N. Dak:	Minot[c]	P	10	11	0(8)	0	17(8)	13
Ohio:	Cincinnati[c]	P	9	9	0(4)	0	3(4)	6
	Cleveland[c]	P	8	9	0(4)	0	10(4)	8
Okla:	Oklahoma City[c]	P	8	10	0(3)	0	16(3)	6
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Ore:	Portland[c]	P	7	8	0(6)	0	6(6)	15
	Baker	P	NA	4	(c)	(c)	16	5
	Coos Bay	P	NA	10	(c)	(c)	18	3
	Eugene	P	NA	3	(c)	(c)	20	13
	Medford	P	NA	3	(c)	(c)	(c)	9
	Portland composite	P	NA	7	(c)	(c)	16	8
	Portland local	P	NA	5	(c)	(c)	16	9
	Redmond	R	NA	4	(c)	(c)	(c)	3
	Tillamook	P	NA	10	(c)	(c)	18	25
Pa:	Philadelphia[c]	P	8	10	0(4)	0	6(4)	9
	Pittsburgh[c]	P	14	13	0(5)	0	6(4)	12
	Dauphin	P	6	8	0	0	0	16
	Erie	P	NA	13	0	0	NA	22
	Philadelphia	P	13(3)	10	0	0	15(3)	18
	Pittsburgh	P	14(5)	12	0	0	15(5)	15
R.I:	Providence[c]	P	8	11	0(4)	0	18(4)	19
S.C:	Charleston[c]	P	11	14	0(3)	0	23(3)	26
S. Dak:	Rapid City[c]	P	6	9	0(7)	0	16(7)	11
Tenn:	Chattanooga[c]	P	12	13	0(4)	0	14(4)	13
	Memphis[c]	P	8	11	0(4)	0	10(4)	6
	Chattanooga	P	11	12	0(4)	0	18(4)	17
	Clinton	P	13	13	0(2)	0	14(2)	20
	Knoxville	P	9	11	0(5)	3	18(5)	16
	Nashville	P	8	8	0(3)	0	8(3)	11
Tex:	Austin[c]	P	0	3	0(4)	0	4(4)	2
	Dallas[c]	P	5	8	0(5)	0	4(5)	6
	Amarillo	R	2	4	0	0	0	2
	Corpus Christi	R	NS	4	NS	0	NS	0
	El Paso	R	NS	2	NS	0	NS	0
	Fort Worth	R	NS	7	NS	0	NS	0
	Harlingen	R	2	4	0	0	0	0
	Houston	R	NS	11	NS	0	NS	14
	Lubbock	R	NS	4	NS	0	NS	0
	Midland	R	NS	3	NS	0	NS	0
	San Antonio	R	2	3	0	0	0	0
	Texarkana	R	9	12	0	0	15	16
	Uvalde	R	NS	3	NS	0	NS	0
	Wichita Falls	R	NS	10	NS	0	NS	0
Utah:	Salt Lake City[c]	P	4	5	0(6)	0	11(6)	12
Vt:	Burlington[c]	P	10	11	0(5)	0	19(5)	10
Va:	Norfolk[c]	P	10	11	0(4)	0	2(4)	9
Wash:	Seattle[c]	P	8	8	0(7)	0	11(7)	22
	Spokane[c]	P	7	6	0(8)	0	13(8)	10
	Benton County	R	NS	0	NS	0	NS	6
	Deer Park	R	4	3	0	0	(c)	3
	Elma	R	5	5	0	0	(c)	12
	Franklin County	R	0	0	0	0	(c)	(c)
	Moses Lake	R	0	1	0	0	(c)	(c)
	Pierce County	R	5	4	0	0	(c)	9
	Sandpoint, Idaho	R	9	8	0	0	25	23
	Skagit County	R	4	4	0	0	(c)	12
W.Va:	Charleston[c]	P	9	12	0(3)	0	4(3)	5
Wisc:	Milwaukee[c]	P	7	8	0(4)	0	13(4)	11
Wyo:	Laramie[c]	P	6	4	0(3)	0	16(3)	10
CANADA								
Alberta:	Calgary	R	6	8	(d)		16	19
	Edmonton	R	8	8	(d)		26	22
British Columbia:	Vancouver	R	14	14	(d)		50	51
Manitoba:	Winnipeg	R	8	8	(d)		32	25
New Brunswick:	Fredericton	R	12	15	(d)		29	25

See footnotes at end of table.

Table 3. Concentrations of radionuclides in milk for December 1968 and 12-month period, January through December 1968—Continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA—Continued								
Newfoundland:	St. Johns	R	15	21	[d]		40	44
Nova Scotia:	Halifax	R	8	12	[d]		23	24
Ontario:	Ft. William	R	13	16	[d]		38	31
	Ottawa	R	8	9	[d]		18	20
	Sault Ste. Marie	R	16	15	[d]		38	33
	Toronto	R	4	5	[d]		24	17
	Windsor	R	5	6	[d]		19	14
Quebec:	Montreal	R	9	10	[d]		20	21
	Quebec	R	10	13	[d]		29	29
Saskatchewan:	Regina	R	6	8	[d]		16	17
	Saskatoon	R	11	9	[d]		21	19
CENTRAL AND SOUTH AMERICA								
Columbia:	Bogota	P	NS	1	NS	0	NS	2
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Montego Bay	P	7	5	0	0	235	109
Venezuela:	Caracas	P	0	1	0	0	0	0
Canal Zone:	Cristobal[e]	P	0	2	0(5)	1	18(5)	11
Puerto Rico:	San Juan[e]	P	5	4	0(5)	0	4(5)	9
PMN network averages:[f]			8	9	0	0	11	12

[a] P, pasteurized milk; R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter; Michigan—14 pCi/liter; Oregon—15 pCi liter

Cesium-137: Colorado—25 pCi/liter; New York—20 pCi/liter; Oregon—15 pCi/liter; Washington—15 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS pasteurized milk network stations denoted by footnote [c].

NA no analysis.

NS, no sample collected.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

Discussion of current data

In table 3, surveillance results are given for strontium-90, iodine-131, and cesium-137, for December 1968 and the 12-month period, January 1968 to December 1968. Except where noted the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 3 since levels at the great majority of the stations for December 1968 were below the respective practical reporting levels. Table 4 gives monthly averages for those stations at which strontium-89 or barium-140 were detected.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of

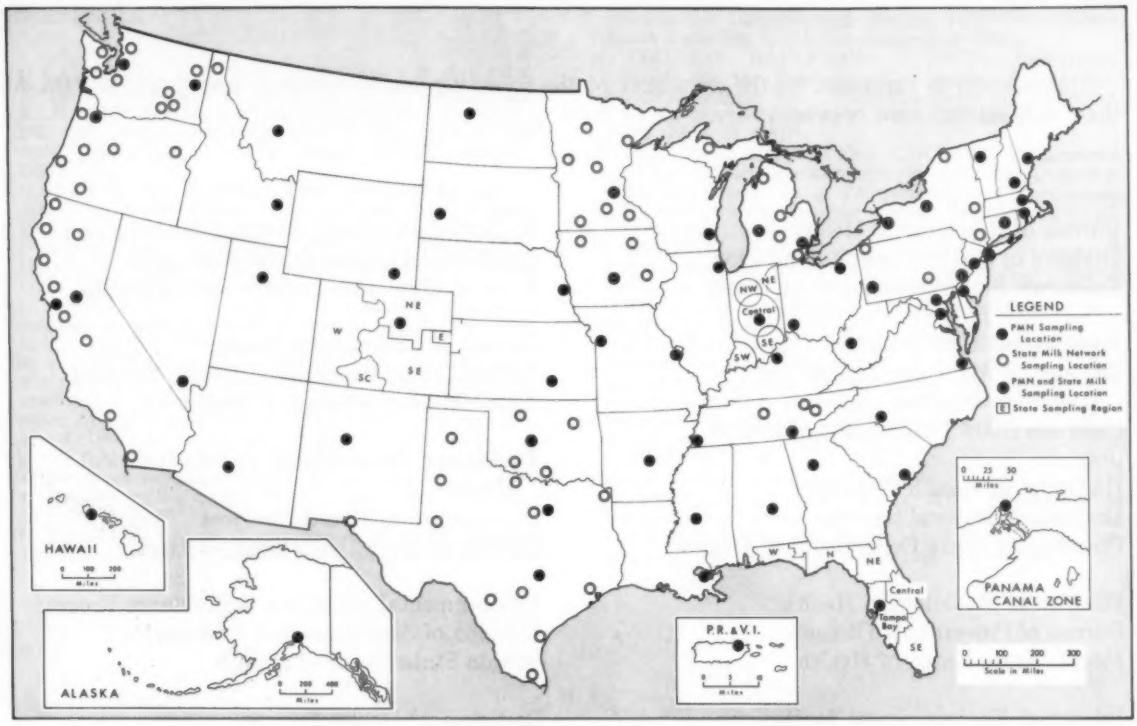

Figure 2. State and PMN milk sampling locations in the United States

Table 4. Strontium-89 and barium-140 in milk December 1968

Sampling location	Monthly average concentration (pCi/liter)	
	Strontium-89	Barium-140
C. Z: Cristobal (PMN)	8	
Calif: Del Norte (State)	6	
Los Angeles (State)		19
Mendocino (State)		15
Sacramento (State)		13
Sacramento (PMN)		3(4)
Santa Clara (State)		17
Shasta (State)		14
Sonoma (State)		11
Conn: Central (State)		5(3)
Fla: Northeast (State)		16
Central (State)		18
Nebr: Omaha (PMN)		4(4)
Tenn: Clinton (State)	6	

particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 35 pCi/liter in the United States for the month of December 1968 and the highest 12-month average was 21 pCi/liter (Little Rock, Ark., Del Norte, Calif.), representing 10.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 81 pCi/liter in the United States for the month of December 1968 and the highest 12-month average was 109 pCi/liter (Southeast Florida), representing 3.0 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 results for individual samples were generally below the practical reporting level. The following station averages reflect samples in which iodine-131 was detected: Central Connecticut (State) 4 pCi/liter, 3 samples; Portland, Maine (PMN) 1 pCi/liter, 5 samples.

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Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiological Health Section
Division of Air, Occupational and Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation and Occupational Health Section
Division of Environmental Sanitation
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

REFERENCES

(1) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1959. Amer J Public Health 49:225 (February 1959).
(2) Chart of the Nuclides, Ninth Edition, Revised to July 1966. Knolls Atomic Power Laboratory (November 1966).
(3) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).
(4) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).
(5) KAUFFMAN, P. and F. KNOWLES. Interlaboratory study of iodine-131, cesium-137 and strontium-90 measurements in milk, March–April 1967. Technical Experiment M–1–67, Analytical Quality Control Service, National Center for Radiological Health (August 1967).
(6) NEILL, R. H. and D. R. SNAVELY. State Health Department sampling criteria for surveillance of radioactivity in milk. Radiol Health Data Rep 8:621–627 (November 1967).
(7) ROBINSON, P. B. A comparison of results between the Public Health Service raw milk and pasteurized milk networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).
(8) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).
(9) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).
(10) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).
(11) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action guides for strontium-89, strontium-90, and cesium-137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).
(12) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER, and B. KAHN. The Cause of Relatively High Cesium-137 Concentrations in Tampa, Florida, Milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

FOOD AND DIET SURVEILLANCE

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	July–October 1967	May 1968

1. Radionuclides in Institutional Diet Samples July–September 1968

Bureau of Radiological Health and
Bureau of Community Environmental Management

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated it's Institutional Diet Sampling Program in 1961. This program is administered by the Bureau of Radiological Health with the assistance of the Bureau of Community Environmental Management (*1*).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsquent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 basic institutions, and 8 auxiliary institutions, distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1*, *2*). Consequently, estimates for boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week, (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period and is then

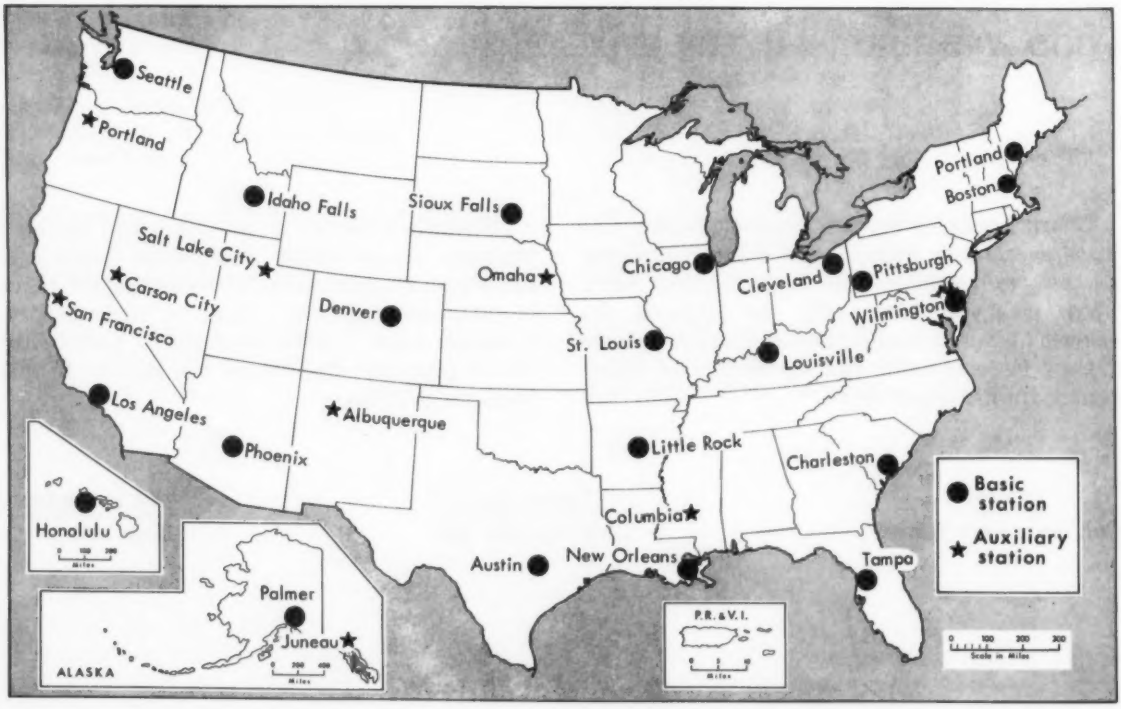

Figure 1. Institutional diet sampling locations as of July–September 1968

packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev; the Southeastern Radiological Health Laboratory, Montgomery, Ala; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented earlier (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from April through June 1968, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of these samples, reported in

Table 1. Concentrations and intake of stable elements and radionuclides in Institutional total diets of children (9–12 years of age), July–September 1968

Location of Institution		Month (1968)	Total weight (kg/day)	Calcium		Potassium		Strontium-90		Cesium-137		Radium-226	
				g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska:	Palmer	July	1.33	0.6	0.8	1.3	1.8	11	14	25	33	0.4	0.5
		Aug [a]	1.67	.6	.9	1.2	2.0	10	17	23	38	.4	.7
		Sept	1.16	.4	.5	1.3	1.5	7	8	18	21	.5	.6
Aris:	Phoenix	Aug	1.79	.6	1.1	1.3	2.3	7	12	0	0	.7	1.3
		Sept	1.74	.6	1.0	.9	1.6	5	9	0	0	.7	1.2
Ark:	Little Rock	July	1.65	.5	.8	1.3	2.2	11	19	0	0	.3	.5
		Aug	1.43	.5	.7	1.3	1.8	18	25	11	16	.5	.7
		Sept	1.57	.4	.6	1.4	2.1	7	11	0	0	.5	.8
Calif:	Los Angeles	July	1.46	.5	.7	1.2	1.7	4	6	0	0	.4	.6
		Aug	1.50	.6	.9	1.4	2.1	4	6	0	0	.5	.8
		Sept [a]	1.81	.5	.9	1.2	2.1	5	9	0	0	.5	.9
Colo:	Denver	July	2.45	.7	1.8	1.5	3.7	6	14	13	32	.4	1.0
		Aug	2.30	.8	1.8	1.7	3.9	6	15	15	35	.5	1.2
		Sept	2.48	.5	1.3	1.4	3.4	5	13	13	32	.4	1.0
Del:	Wilimington	July	2.07	.7	1.3	1.7	3.4	9	19	11	23	.9	1.9
		Aug	2.16	.7	1.4	1.7	3.6	7	15	14	30	.8	1.7
		Sept	2.04	.6	1.3	1.7	3.5	10	20	0	0	.7	1.4
Fla:	Tampa	July	1.50	.5	.7	1.5	2.2	7	11	34	51	.7	1.1
		Aug	1.54	.5	.7	1.6	2.5	10	15	35	54	.6	.9
		Sept	1.54	.5	.8	1.6	2.5	8	13	32	49	.9	1.4
Hawaii:	Honolulu	July	2.45	.5	1.2	1.5	3.6	5	12	25	61	.6	1.5
		Aug	2.41	.6	1.4	1.3	3.2	4	9	19	46	.5	1.2
		Sept	2.42	.4	1.0	1.2	4.0	4	10	19	46	.5	1.2
Idaho:	Idaho Falls	July [a]	2.19	1.0	2.3	1.3	2.9	7	16	20	44	.5	1.1
		Aug [a]	1.69	.8	1.4	1.4	2.3	7	13	13	22	.6	1.0
		Sept [a]	1.78	1.3	2.3	1.7	3.0	10	18	13	23	.9	1.6
Ill:	Chicago	July [a]	1.39	.6	.8	1.7	2.3	7	10	12	17	1.1	1.5
		Aug	NS										
		Sept	NS										
Ky:	Louisville	July	1.62	.5	.8	1.5	2.4	9	14	0	0	.7	1.1
		Aug	1.63	.6	.9	1.7	2.7	6	9	0	0	.6	1.0
		Sept	1.70	.7	1.1	1.6	2.6	11	19	0	0	1.0	1.7
La:	New Orleans	July	1.63	.5	.8	1.8	3.0	11	18	16	26	.4	.7
		Aug	2.03	.5	1.1	1.4	2.9	7	15	12	24	.3	.6
		Sept	1.87	.5	1.0	1.6	3.0	9	16	15	28	.4	.7
Maine:	Portland	July	1.52	.8	1.2	1.5	2.2	16	24	26	40	1.0	1.5
		Aug	1.80	.8	1.4	1.5	2.7	12	22	25	45	.7	1.3
		Sept	1.62	.8	1.3	1.7	2.8	13	21	24	39	.8	1.3
Mass:	Boston	July	1.94	.7	1.4	1.7	3.3	12	24	28	54	.8	1.6
		Aug	1.55	.4	.7	1.6	2.5	8	12	22	34	.8	1.2
		Sept	1.70	.6	1.0	1.4	2.4	9	15	22	37	.5	.9
Mo:	St. Louis	July	2.31	1.2	2.7	1.6	3.6	11	25	0	0	.3	.7
		Aug [a]	2.04	1.2	2.5	1.5	3.1	9	18	17	35	.8	1.6
		Sept	2.80	1.1	3.1	1.6	4.5	8	22	18	50	.6	1.7
Ohio:	Cleveland	July	1.57	.7	1.1	1.6	2.6	8	12	13	20	.8	1.3
		Aug	1.65	.9	1.5	1.7	2.8	8	13	16	26	.7	1.2
		Sept	1.23	.6	.7	1.5	1.8	6	7	0	0	.5	.6
Pa:	Pittsburgh	July	2.38	.5	1.3	1.6	3.7	9	21	0	0	.7	1.7
		Aug	2.23	.5	1.2	1.5	3.2	7	16	0	0	.7	1.6
		Sept	2.25	.6	1.2	1.2	2.7	8	18	0	0	.9	2.0
S. C:	Charleston	July	1.52	.7	1.1	1.4	2.1	13	20	20	30	.8	1.2
		Aug	2.17	.6	1.4	1.2	2.5	8	18	20	43	.5	1.1
		Sept	1.53	.7	1.1	1.5	2.3	9	14	21	32	.8	1.2
S. Dak:	Sioux Falls	July	1.06	.9	.9	1.6	1.7	7	8	0	0	.5	.5
		Aug [a]	1.27	.8	1.0	1.3	1.6	6	8	18	23	1.4	1.8
		Sept [a]	1.73	.7	1.2	1.3	2.2	6	10	12	21	.9	1.6
Tex:	Austin	July	1.81	.7	1.3	1.7	3.0	4	8	0	0	.3	.5
		Aug	1.32	.7	.9	1.5	2.0	5	6	0	0	.3	.4
		Sept	1.91	.9	1.8	1.6	3.0	6	12	0	0	.4	.8
Wash:	Seattle	July	NS										
		Aug [a]	2.25	.5	1.1	1.2	2.6	7	15	0	0	.5	1.1
		Sept [a]	1.96	.5	1.0	1.5	2.9	6	11	18	35	.7	1.4
Institutional average		July	1.78	0.7	1.2	1.5	2.7	9	16	12	22	0.6	1.0
		Aug	1.83	0.6	1.1	1.5	2.7	8	14	13	24	0.6	1.1
		Sept	1.85	0.6	1.2	1.4	2.7	8	14	11	21	0.6	1.2

[a] Since food samples were collected from two or more children who were not between the ages of 9–12, data for this month were not used in institutional average.

NS, no sample.

Note: Since iodine–131, barium–140 and strontium–89 were not detectable at most stations during the third quarter of 1968, no provision was made for these nuclides in the table. The few exceptions are as follows: strontium–89 was reported in July for Idaho, 6 pCi/kg. Barium–140 was reported in July for Massachusetts, 20 pCi/kg. Barium–140 was reported in August for Delaware, 19 pCi/kg and Maine, 14 pCi/kg. Barium–140 was also reported in September for Missouri, 20 pCi/kg; Ohio, 21 pCi/kg; and Pennsylvania, 11 pCi/kg.

Table 2. Concentrations and intake of stable elements and radionuclides in Institutional total diets of children July–September 1968

Location of Institution	Month (1968)	Total weight (kg/day)	Calcium		Potassium		Strontium-90		Cesium-137		Radium-226	
			g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska: Juneau	July	1.22	0.6	0.7	1.5	1.8	8	10	13	16	0.5	0.6
	Aug	1.24	.6	.7	1.6	1.9	11	14	24	30	.5	.6
	Sept	1.22	.6	.7	1.5	1.8	6	7	19	23	.6	.7
Calif: San Francisco	July	2.39	.5	1.2	1.4	3.4	4	11	11	26	.5	1.2
	Aug	2.32	.7	1.6	1.5	3.4	5	12	0	0	.5	1.2
	Sept	1.86	.4	.7	1.8	3.3	4	7	0	0	.7	1.3
Miss: Columbia	July	2.63	.7	1.9	1.4	3.7	12	32	16	42	.2	.5
	Aug	2.35	.9	2.1	1.8	4.1	12	28	14	33	.7	1.6
	Sept	1.74	.7	1.3	1.6	2.8	11	19	13	23	.6	1.0
Nebr: Omaha	July	2.18	.7	1.4	1.3	2.9	6	13	12	26	1.2	2.6
	Aug	1.92	1.0	1.9	1.7	3.3	7	14	0	0	.9	1.7
	Sept	2.13	.8	1.7	1.4	3.0	5	11	0	0	.7	1.5
Nev: Carson City	July	1.94	.7	1.4	1.6	3.1	4	8	13	25	.4	.8
	Aug	1.59	.7	1.2	1.7	2.8	3	5	0	0	.7	1.1
	Sept	1.46	.6	.9	1.5	2.2	5	7	11	16	.5	.7
N. Mex: Albuquerque	July	NS										
	Aug	.92	.5	.5	1.9	1.7	8	7	0	0	.6	.6
	Sept	2.20	.5	1.2	1.6	3.5	5	10	0	0	.3	.7
Ore: Portland	July	2.08	.4	.8	1.9	4.0	3	6	25	52	.3	.6
	Aug	2.47	.6	1.6	1.8	4.5	3	8	17	42	.4	1.0
	Sept	2.35	.6	1.3	1.6	3.6	3	8	20	47	.5	1.2
Utah: Salt Lake City	July	1.90	.6	1.2	1.3	2.5	6	11	12	23	.4	.8
	Aug	1.90	.6	1.0	1.3	2.4	5	9	0	0	.3	.6
	Sept	1.67	.6	1.0	1.3	2.2	4	7	11	18	.4	.7
Institutional average	July	2.05	0.6	1.2	1.5	3.1	6	13	15	30	0.5	1.0
	Aug	1.84	0.7	1.3	1.6	3.0	7	12	7	13	0.6	1.0
	Sept	1.83	0.6	1.1	1.5	2.8	5	10	9	16	0.5	1.0

NS, no sample.

pCi/kg of diet, are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes, in g/day or pCi/day, were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.82 kg/day compared to the network average of 1.86 kg/day observed from 1961 through 1967.

Strontium-90 dietary intake during this period averaged 8 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (4). Cesium-137 intakes averaged 12 pCi/day during this period. Strontium-89, barium-140, and iodine-131 concentrations were generally below detectable levels.

All concentrations that are less than or equal to the appropriate minimum detectable level will be reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2-standard deviation analytical error. Accordingly, the minimum detectable limits are as follows:

Strontium-89	5 pCi/kg
Strontium-90	2 pCi/kg
Iodine-131	10 pCi/kg
Cesium-137	10 pCi/kg
Barium-140	10 pCi/kg
Radium-226	0.1 pCi/kg

Data from eight axuiliary stations is included in a separate table for general information. This is presented in table 2. These stations do not meet the criterion that the majority of the samples are collected from children who range in age from 9 to 12 years. In order to supplement the existing environmental monitoring networks of the Bureau of Radiological Health, these eight institutions are being sampled in the same manner as the basic stations.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December and Annual Summary 1967	July 1968
January–March 1968	October 1968
April–June 1968	January 1969

REFERENCES

(1) ANDERSON, E. C., D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(2) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Radiol Health Data 6:548–554 (October 1965).

(3) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1968. Radiol Health Data 9:557–560 (October 1968).

(4) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

2. Strontium-90 in Tri-City Diets[1] February–June 1968

Health and Safety Laboratory
U.S. Atomic Energy Commission

Estimates of the average intake of strontium-90 by New York City, Chicago, and San Francisco residents have been made by the Health and Safety Laboratory (HASL). These estimates were made by using measurements of the strontium-90 content of a large variety of foods purchased at the cities every 3 months and statistics on the average consumption of each food compiled by the U.S. Department of Agriculture in their 1955 Household Diet Survey (1). A detailed description of the aims and methods of the HASL diet sampling program along with a summary of the results obtained during the first 3 years of operation (1960–1963) was published earlier (2).

Starting in 1968, two changes have been made in the program. The first is the suspension of the collection and analyses of foods purchased in Chicago because previous experience had shown the levels of strontium-90 in the Chicago diet to be consistently between those of New York City and San Francisco. Thus, reasonable estimates of the dietary intake of strontium-90 in Chicago at any time can be made from the analyses of foods purchased in New York and San Francisco.

The second change, revision of the estimates of the annual consumption of different diet components, was made because new information became available. This new information on the composition of the diet appeared in a preliminary report of the U.S. Department of Agriculture on their 1965 Household Diet Survey (3). The changes in the composition of the diet from 1955 to 1965 are not very great and the estimates of strontium-90 intake made using statistics from either diet survey are not too different. Estimates of the intakes of other nuclides, however, may be effected to a greater degree. The new estimates of consumption have therefore been used to calculate the intakes of calcium and strontium-90 for the first and second quarters of 1968 in New York City and San Francisco.

Results of the February–March 1968 samplings are presented in table 1; May–June 1968 in table 2. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1.

[1] Data from "Fallout Program Quarterly Summary Report, HASL-200." Available from the Clearinghouse for Federal Scientific & Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

Table 1. Average dietary consumption and strontium-90 intake in Tri-City diet February–March 1968[a]

Food category	Diet (kg/yr)	Calcium (g/yr)	New York City		San Francisco	
			February 1968		March 1968	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Dairy products	200	216.0	8.0	1,600	3.3	660
Fresh fruit	59	9.4	15.3	903	1.7	100
Fresh vegetables	48	18.7	9.9	475	2.7	130
Root vegetables	10	3.8	14.5	145	3.5	35
Potatoes	38	3.8	14.2	540	3.6	137
Macaroni	3	.6	3.4	10	2.6	8
Rice	3	1.1	2.1	6	1.5	5
Fruit juices	28	2.5	3.8	106	2.9	81
Canned vegetables	22	4.4	10.2	224	3.7	81
Canned fruit	11	.6	3.6	40	1.2	13
Dried beans	3	2.1	40.7	122	24.8	74
Flour	34	6.5	8.6	292	2.8	95
Bakery products	44	53.7	8.5	374	3.9	172
Whole grain products	11	10.3	12.4	136	7.0	77
Fresh fish	8	7.6	.6	5	.5	4
Shell fish	1	1.6	1.4	1	.7	1
Poultry	20	6.0	1.5	30	1.8	36
Meat	79	12.6	.7	55	.4	32
Eggs	15	8.7	3.1	47	1.4	21
Annual intake (pCi/yr)		370.0		5,111		1,762
Daily intake (pCi/day)				14.0		4.8

[a] January 1968 data not available.

Table 2. Average dietary consumption and strontium-90 intake in Tri-City diet May–June 1968

Food category	Diet (kg/yr)	Calcium (g/yr)	New York City May 1968		San Francisco June 1968	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Dairy products	200	216.0	9.8	1,960	1.4	280
Fresh fruit	59	9.4	12.3	726	2.0	118
Fresh vegetables	48	18.7	20.1	965	4.6	221
Root vegetables	10	3.8	8.1	81	4.1	41
Potatoes	38	3.8	8.4	319	3.1	118
Macaroni	3	.6	3.4	10	3.9	12
Rice	3	1.1	1.2	4	1.6	5
Fruit juices	28	2.5	3.2	90	2.4	67
Canned vegetables	22	4.4	6.6	145	3.6	79
Canned fruit	11	.6	1.8	20	.9	10
Dried beans	3	2.1	29.2	61	6.7	20
Flour	34	6.5	7.3	248	3.6	122
Bakery products	44	53.7	5.2	229	3.5	154
Whole grain products	11	10.3	11.9	131	6.6	73
Fresh fish	8	7.6	.8	6	.3	2
Shell fish	1	1.6	1.5	2	.2	0
Poultry	20	6.0	2.5	50	3.6	72
Meat	79	12.6	.7	55	.3	24
Eggs	15	8.7	2.7	41	1.9	29
Annual intake (pCi/yr)		370.0		5,143		1,447
Daily intake (pCi/day)				14.1		4.0

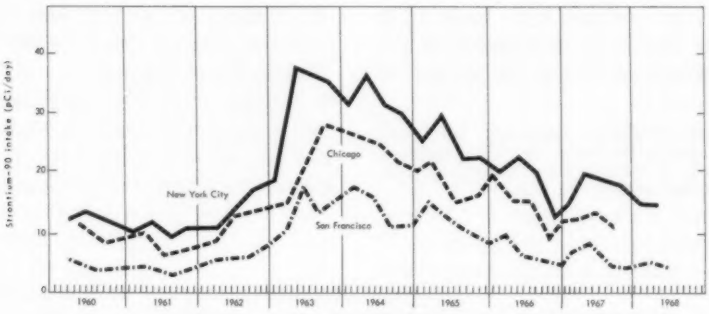

Figure 1. Daily intake of strontium-90 in Tri-City diet March 1960–June 1968

REFERENCES

(*1*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, Report No. 1, (1955). Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (December 1956).

(*2*) RIVERA, J., and J. H. HARLEY. HASL contributions to the study of fallout in food chains, HASL–147. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1964).

(*3*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, spring 1965. A preliminary report, USDA, ARS 62–16 (August 1967).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1967	March 1968
April–December 1967	June 1968

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Last presented
California	July–December 1967	November 1968
Coast Guard	January–December 1967	February 1969
Florida	1967	February 1969
Minnesota	January–June 1968	February 1969
Washington	July 1966–June 1967	August 1968

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, October 1968

Division of Pollution Surveillance
Federal Water Pollution Control Administration, Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System currently operated by the Federal Water Pollution Control Administration. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the November 1968 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public

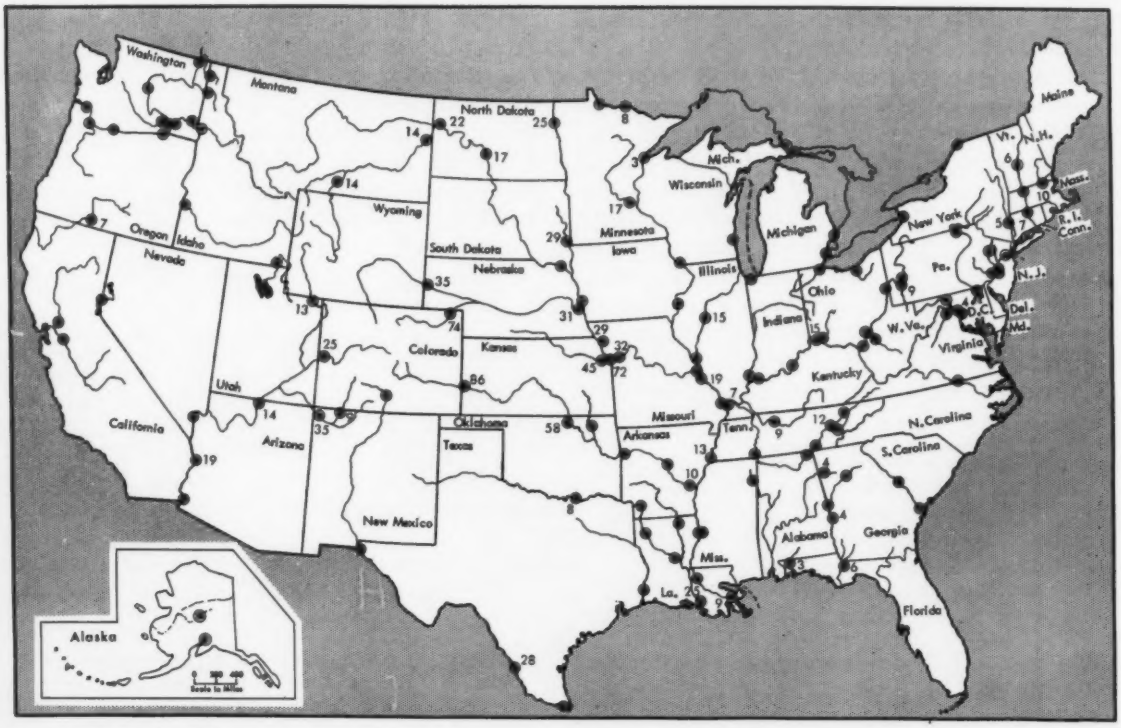

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, October 1968

Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During October 1968, the following stations showed values in excess of 15 pCi/liter on alpha radioactivity for either suspended or dissolved solids:

Arkansas River; Coolidge, Kans.
Colorado River; Loma, Colo.
North Platte River; Henry, Nebr.
South Platte River: Julesburg, Colo.

During October 1968, no station showed a gross beta radioactivity in excess of 150 pCi/liter.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*2*) *Ibid.*, 1959 Edition.
(*3*) *Ibid.*, 1960 Edition.
(*4*) *Ibid.*, 1961 Edition.
(*5*) *Ibid.*, 1962 Edition.
(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*7*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1-15 (January 1968).

Table 1. Radioactivity in raw surface waters, October 1968

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	0	1	1	1	8	9
Apalachicola River:						
Chattahoochee, Fla	0	0	0	3	3	6
Arkansas River:						
Coolidge, Kans	2	47	49	10	76	86
Ponca City, Okla	8	1	9	48	10	58
Pendleton Ferry, Ark	0	0	0	0	10	10
Atchafalaya River:						
Morgan City, La	4	1	5	16	9	25
Big Horn River:						
Hardin, Mont	0	1	1	1	13	14
Big Sioux River:						
Sioux Falls, S. Dak	1	1	2	5	24	29
Chattahoochee River:						
Columbus, Ga	0	0	0	0	4	4
Clinch River:						
Kingston, Tenn[a]	<1	<1	<1	2	10	12
Colorado River:						
Loma, Colo	2	15	17	10	15	25
Page, Ariz	0	4	4	<1	14	14
Parker Dam, Calif–Ariz	0	8	8	1	18	19
Connecticut River:						
Wilder, Vt	0	0	0	0	6	6
Enfield Dam, Conn	0	0	0	1	6	7
Coosa River:						
Rome, Ga	0	<1	<1	1	3	4
Cumberland River:						
Cheatham Lock, Tenn	0	0	0	0	9	9
Escambia River:						
Century, Fla	0	0	0	0	3	3
Great Lakes:						
Duluth, Minn	0	0	0	0	3	3
Green River:						
Dutch John, Utah	0	2	2	<1	13	13
Hudson River:						
Poughkeepsie, N.Y	0	0	0	1	4	5
Illinois River:						
Peoria, Ill	1	0	1	4	11	15
Kansas River:						
DeSoto, Kans	10	2	12	33	12	45
Klamath River:						
Keno, Ore	0	0	0	1	6	7
Merrimack River:						
Lowell, Mass	0	0	0	2	8	10
Mississippi River:						
St. Paul, Minn	0	3	3	1	16	17
E. St. Louis, Ill	1	1	2	8	11	19
W. Memphis, Ark	0	1	1	5	8	13
New Orleans, La	0	0	0	0	9	9
Missouri River:						
Williston, N. Dak	1	3	4	4	18	22
Bismarck, N. Dak	<1	3	3	3	15	18
St. Joseph, Mo	3	2	5	14	15	29
Missouri City, Mo	5	4	9	13	19	32
Monongahela River:						
Pittsburgh, Pa	0	0	0	0	9	9
North Platte River:						
Henry, Nebr	<1	16	16	5	30	35
Ohio River:						
Cincinnati, Ohio	0	1	1	2	13	15
Cairo, Ill	0	0	0	1	6	7
Platte River:						
Plattsmouth, Nebr	3	4	7	11	20	31
Potomac River:						
Washington, D.C	0	0	0	1	6	7
Rainy River:						
International Falls, Minn	0	0	0	0	8	8
Red River, North:						
Grand Forks, N. Dak	0	1	1	3	22	25
Red River, South:						
Denison, Tex	0	3	3	1	7	8
Rio Grande:						
Laredo, Tex	3	4	7	15	13	28
San Juan River:						
Shiprock, N. Mex	8	2	10	19	16	35
South Platte River:						
Julesburg, Colo	1	31	32	8	66	74
Yellowstone River:						
Sidney, Mont	0	0	0	2	12	14
Maximum	13	47	49	50	76	86
Minimum	0	0	0	0	3	3

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

Radioactivity in New York Surface Water, January-June 1968

Division of General Engineering and Radiological Health
State of New York Department of Health

In 1955, the New York State Department of Health began a program to determine the amount of radioactivity in water used for public consumption. Radioactivity in water may arise from any one or a combination of the following sources: the natural mineral content of water (background), atmospheric fallout, or nuclear industry operations. Water samples are obtained from 23 locations for gross beta-particle analysis (figure 1). Table 1 gives the number of samples, quarterly values, and type of sample. Larger samples are collected at selected locations for strontium-89 and strontium-90 analysis. A new analysis of tritium at selected locations is included in this report.

Analytical procedures

Strontium and other alkaline earths are precipitated as carbonates from a 500-ml sample. Iron and rare earths are removed by hydroxide scavenging, while barium is precipitated as a chromate. Strontium is finally precipitated as a sulphate from a pH controlled EDTA solution. Calcium and yttrium remain in solution as EDTA complexes (*1–2*).

Strontium-90 is determined by yttrium-90 ingrowth counting of the final precipitate at less than 6 hours after precipitation and again at greater than 50 hours using a low background (less than 1 cpm) gas-flow, proportional beta-particle counter. Strontium-89 is estimated by taking the difference between the total strontium and the strontium-90 radioactivity.

Chemical recovery is between 70 and 75 percent and results in a minimum detectable radioactivity of 3 pCi/liter ± 100 percent at the 95-percent confidence level.

Discussion and results

Quarterly average, maximum, and minimum gross beta-particle concentrations in New York

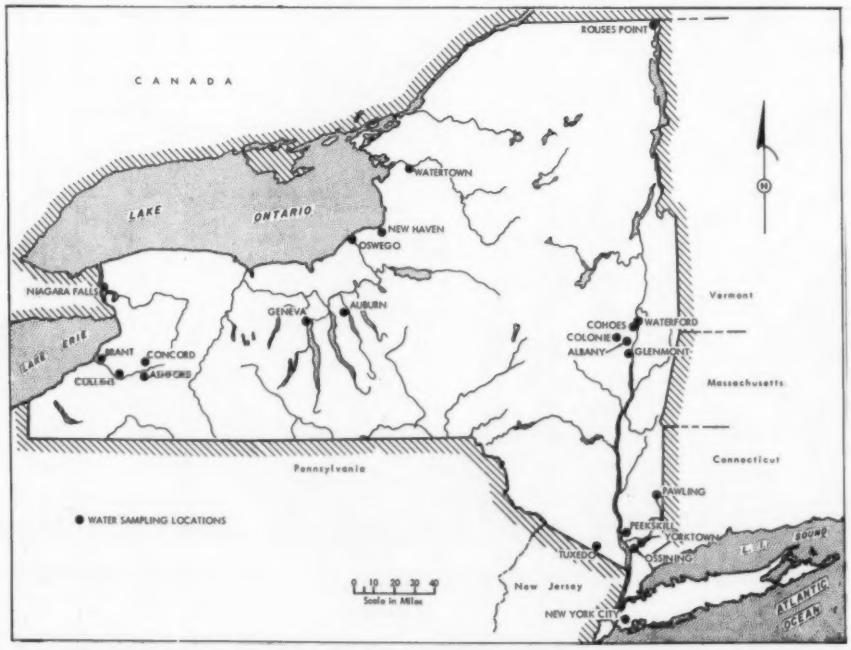

Figure 1. New York water sampling locations

surface water for January–June 1968 are given in table 1. The Ashford station at Thomas Corners, Brant, Collins, and Concord stations are located downstream of the Nuclear Fuels Services reprocessing plant and show concentration levels well above natural background. An abnormally high concentration of gross beta radioactivity in one Hudson River sample at Sing Sing is attributed to intrusion of saline water.

The average, maximum, and minimum concentrations of strontium-89 and strontium-90 in New York water for January–June 1968 are given for four stations in table 2.

Tritium concentration values for January–June 1968 are given in table 3 for nine locations. Tritium, the radioactive isotope of hydrogen, a very low-energy beta emitter, is released to the water courses during the reprocessing of nuclear fuel. The tritium concentrations in Cattaraugus and Buttermilk Creeks showed the contribution of the Nuclear Fuels reprocessing plant.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–September 1967	January 1968
June–December 1967	October 1968

Table 1. Gross beta radioactivity in New York raw surface water, January–June 1968[a]

Location	Gross beta radioactivity (pCi/liter)							
	January-March 1968				April-June 1968			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	3	3	3	2	3	3	3	3
Ashford (Buttermilk Creek at Fox Valley Road)	3	10	18	5	3	8	18	4
(Buttermilk Creek at Thomas Corners)	13	1,478	3,262	583	7	1,406	3,923	132
(Cattaraugus Creek)[b]	3	8	12	5	3	3	4	2
Auburn (Owasco Lake)	1	3	3	3	1	4	4	4
Brant (Cattaraugus Creek)	5	59	90	31	12	28	47	15
Cohoes (Filtration Plant)	14	4	8	3	11	3	5	3
Collins (Cattaraugus Creek)	13	72	117	39	11	49	116	15
Colonie (Patroon Creek)	1	17	17	17	1	9	9	9
Concord (Cattaraugus Creek)	41	141	564	5	55	94	287	18
Geneva (Seneca Lake)	2	3	4	3	5	3	4	3
Glenmont (Hudson River)	13	5	8	3	13	4	6	3
New Haven (Lake Ontario)	1	7	7	7	3	4	4	4
New York City	7	4	5	3	4	3	5	2
Niagara Falls (West Branch, Niagara River)	3	3	5	1	2	5	6	4
Ossining (Indian Brook Reservoir)	2	5	5	5	4	5	7	4
(Sing Sing) (Hudson River)	8	19	46	2	15	15	117	9
Oswego	3	4	4	4	2	4	4	4
Pawling (Pond at United Nuclear)	3	42	88	7	3	4	4	3
Peekskill (Camp Field Water Supply)	3	3	4	2	5	4	6	5
(Hudson River)	12	16	52	3	15	6	18	2
Tuxedo (Indian Kill)	3	9	16	5	2	3	4	2
Watertown (Black River)	5	5	9	3	5	3	4	3
Yorktown (Croton Reservoir)	3	3	5	1	4	4	5	3

[a] Excluding tritium.
[b] This station is on the Nuclear Falls Services reprocessing plant site.

Table 2. Strontium-89 and strontium-90 concentration in New York surface waters, January–June 1968

Location	Strontium-89 (pCi/liter)								Strontium-90 (pCi/liter)							
	January-March 1968				April-June 1968				January-March 1968				April-June 1968			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Ashford (Buttermilk Creek at Fox Valley Road)	0	NA	NA	NA	0	NA	NA	NA	3	1	3	3	3	ND	ND	ND
(Buttermilk Creek at Thomas Corners)[a]	2	21	24	18	6	89	452	4	8	269	402	168	9	104	258	ND
Auburn (Owasco Lake)	0	NA	NA	NA		NA	NA	NA	2	<5	9	<5		NA	NA	NA
Concord (Springville Power Dam on Cattaraugus Creek)	0	NA	NA	NA	1	4	4	4	2	28	37	19	2	9	10	7

[a] This station is in the Nuclear Falls Services reprocessing plant site.
NA, no analysis.
ND, nondetectable.

Table 3. Tritium concentration of New York surface waters, January–June 1968

Location	Concentration (pCi/liter)							
	January-March 1968				April-June 1968			
	Number of samples	Average	Maximum	Minimum	Number of samples	Average	Maximum	Minimum
Albany	3	1,836	2,390	1,480	2	1,025	1,360	ND
Ashford (Buttermilk Creek at Fox Valley Road)	2	<1,000	<1,000	<1,000	4	<1,000	1,560	1,010
(Buttermilk Creek at Thomas Corners)[a]	11	141,959	252,620	16,170	12	108,808	591,720	4,960
(Cattaraugus Creek)	3	<1,000	<1,000	<1,000	3	<1,000	1,590	<1,000
Brant (Cattaraugus Creek)	3	5,413	8,800	3,270	13	4,421	10,950	2,270
Cohoes (Filtration Plant)	13	1,204	2,190	<1,000	8	<1,000	1,630	<1,000
Collins (Cattaraugus Creek)	12	8,879	13,920	2,820	14	5,938	15,720	1,900
Concord (Springville Power Dam on Cattaraugus Creek)	40	14,595	27,180	1,960	54	10,709	39,580	12,240
New Haven (Lake Ontario)	1	2,020	2,020	2,020	3	<1,000	<1,000	<1,000

[a] This station is on the Nuclear Falls Services reprocessing plant site.
ND, nondetectable.

REFERENCES

(1) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Improved determination of strontium-90 in milk by ion-exchange method. Anal Chem 33:1306–1308 (September 1961).
(2) WELFORD, G., and D. SUTTON, a paper presented at the American Chemical Society meeting in New York City, September 1960.

Radiostrontium in Tap Water, January-June 1968

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water at New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Cesium-137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Strontium-90 concentration and cesium-137/strontium-90 ratios in New York City tap water for January through July 1968 are presented in table 1. These results appear graphically in figure 1.

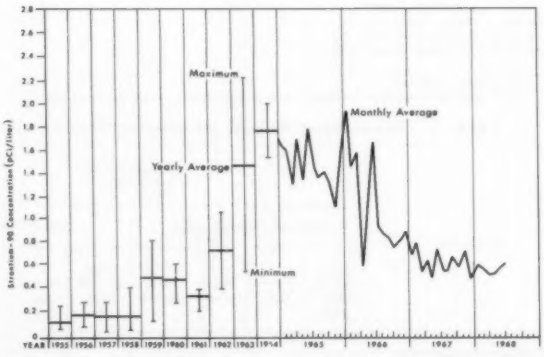

Figure 1. Strontium-90 concentrations in New York City tap water, 1955–June 1968

A decreasing trend has been observed in the strontium-90 concentrations since the July 1963 peak. The maximum strontium-90 concentrations observed are below the acceptable limit as set forth in the Interstate Carrier Drinking Water Standards (*2*).

[1] Prepared from information appearing in "Fallout Program Quarterly Summary Report," HASL-204. This report is available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va., 22151.

Table 1. Radiostrontium in New York City tap water January–June 1968

Date	Strontium-90[a] (pCi/liter)	Cesium-137/ strontium-90
January	0.59	0.09
February	.56	.06
March	.50	.07
April	.51	.11
May	.55	.13
June	.60	.12

[a] Approximately 100 liters per sample.

REFERENCES

(*1*) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures 40:E–38–01–16. Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York, N.Y. 10014.

(*2*) FEDERAL REGISTER RULES AND REGULATIONS. Title 42-Public Health, Chapter 1, Public Health Service, Department of Health, Education and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards 27:2154–5. Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1967	June 1968

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	July–December 1967	September 1968
HASL 80th Meridian Network	Calendar Year 1966	December 1968
Plutonium in Airborne Particulates	January–March 1968	January 1969

1. Radiation Alert Network, December 1968

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection when most of the radon daughter products have decayed, and at 29 hours after collection when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. Compilation of the daily field estimates is reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique during December 1968. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

In response to the execution of Project Schooner by the Atomic Energy Commission at the Nevada Test Site on December 8, 1968, 31 of the 73 RAN stations were requested to modify their routine sampling procedure and collect 12-hour air samples during the week of December 9–13. The operators of these stations were asked to perform a field estimate at either 5 or 12 hours after collection (depending on whether the sample was collected in the morning or at night, respectively) and then to send the filters to RAN headquarters in Rockville, Md. Significantly elevated levels of airborne radioactivity were observed at the following locations during this period.

	Location	Maximum field estimate (pCi/m³)
Idaho:	Boise	457
Colo:	Denver	173

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, December 1968

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Number of samples	Precipitation			
								Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average [a]				Number of samples	Depth (mm)	Total deposition (nCi/m³)
Ala:	Montgomery	26	5	0	1	Sept 68	7	90	7	90	12
Alaska:	Adak	31	2	1	2	Feb 69	[c]				
	Anchorage	11	0	0	0	Oct 68	1	4	[d]		
	Attu Island	31	0	0	0	Mar 69	[c]				
	Fairbanks	[b]				Nov 68	[c]				
	Juneau	21	0	0	0	Dec 68	11	69	11	69	0
	Kodiak	18	2	0	0	Jan 69	[c]				
	Nome	[b]				July 68	[c]				
	Point Barrow	15	1	0	0	Apr 69	[c]				
	St. Paul Island	30	1	1	1	Aug 68	[c]				
Ariz:	Phoenix	20	41	2	9	Dec 68	[c]				
Ark:	Little Rock	7	5	2	3	Oct 68	[c]				
Calif:	Berkeley	22	1	0	0	Jan 69	10	107	10	107	7
	Los Angeles	[b]				July 68	[c]				
C.Z:	Ancon	14	0	0	0	Jan 69	[c]				
Colo:	Denver	26	173	0	10	Jan 69	[c]				
Conn:	Hartford	21	0	0	0	Nov 68	6	101	6	101	0
Del:	Dover	21	1	0	0	Sept 68	[c]				
D.C:	Washington	2	0	0	0	Apr 69	[c]				
Fla:	Jacksonville	23	2	0	0	Oct 68	4	16	4	16	22
	Miami	22	1	0	0	Nov 68	[c]				
Ga:	Atlanta	24	2	1	1	Aug 68	4	142	4	142	112
Guam:	Agana	[b]				Sept 68	[c]				
Hawaii:	Honolulu	20	3	0	0	Mar 69	8	189	[d]		
Idaho:	Boise	27	457	0	19	Mar 69	11	41	11	41	21
Ill:	Springfield	26	3	0	1	Apr 69	1	35	0	0	[e]
Ind:	Indianapolis	26	4	0	1	Aug 68	8	109	8	109	123
Iowa:	Iowa City	23	5	0	1	Jan 69	2	39	1	35	0
Kans:	Topeka	28	5	0	1	Oct 68	4	43	4	43	1
Ky:	Frankfort	19	4	0	1	Apr 69	4	21	4	21	4
La:	New Orleans	23	1	0	0	Apr 69	8	238	[d]		
Maine:	Augusta	20	3	0	1	Dec 68	9	187	9	187	0
Md:	Baltimore	20	1	0	0	Nov 68	3	28	3	28	0
	Rockville	24	1	0	0	Mar 69	[c]				
Mass:	Lawrence	20	0	0	0	Sept 68	6	165	6	165	24
	Winchester	13	0	0	0	Feb 69	5	93	5	93	0
Mich:	Lansing	21	3	0	1	Mar 69	[c]				
Minn:	Minneapolis	21	1	0	0	Sept 68	8	34	8	34	1
Miss:	Jackson	20	2	0	1	Dec 68	5	229	5	229	164
Mo:	Jefferson City	26	1	0	0	Aug 68	5	64	5	64	0
Mont:	Helena	26	179	0	8	Feb 69	4	11	4	11	26
Nebr:	Lincoln	27	4	0	1	Aug 68	3	53	3	53	12
Nev:	Las Vegas	20	9	1	2	Nov 68	[c]				
N.H:	Concord	19	1	0	0	Apr 69	[c]				
N.J:	Trenton	26	1	0	0	Dec 68	5	48	5	48	28
N. Mex:	Santa Fe	21	3	0	1	Feb 69	4	26	4	26	2
N.Y:	Albany	19	1	0	0	Aug 68	8	91	8	91	79
	Buffalo	19	2	0	0	Jan 69	[c]				
	New York City	19	1	0	0	Feb 69	[c]				
N.C:	Gastonia	17	19	1	5	Jan 69	1	7	[d]		
N.Dak:	Bismarck	26	4	0	1	Apr 69	5	13	5	13	0
Ohio:	Cincinnati	9	2	0	1	Sept 68	[c]				
	Columbus	20	2	0	0	Dec 68	5	48	3	29	0
	Painesville	21	1	0	1	Nov 68	9	9	9	9	7
Okla:	Oklahoma City	22	3	0	0	Mar 69	3	40	3	40	0
	Ponca City	26	5	0	1	Nov 68	6	34	6	34	0
Ore:	Portland	20	5	0	0	Aug 68	18	140	18	140	18
Pa:	Harrisburg	18	1	0	0	Aug 68	[c]				
P.R:	San Juan	[b]				Dec 68	[c]				
R.I:	Providence	19	1	0	0	Mar 69	8	145	8	145	52
S.C:	Columbia	25	4	0	0	Feb 69	6	57	6	57	12
S. Dak:	Pierre	26	65	0	5	Dec 68	[c]				
Tenn:	Nashville	18	2	0	1	Mar 69	6	85	6	85	0
Tex:	Austin	17	8	0	2	Sept 68	3	68	[d]		
	El Paso	20	10	0	4	Apr 69	[c]				
Utah:	Salt Lake City	36	167	0	6	July 68	8	39	8	39	25
Vt:	Barre	16	1	0	0	Oct 68	8	106	8	106	0
Va:	Richmond	17	1	0	0	Oct 68	4	12	4	12	2
Wash:	Seattle	20	0	0	0	Oct 68	14	144	[d]		
	Spokane	18	44	0	2	Sept 68	5	25	5	25	82
W. Va:	Charleston	26	2	0	0	Feb 69	7	50	7	50	5
Wisc:	Madison	18	2	0	0	Oct 68	7	68	7	68	61
Wyo:	Cheyenne	28	171	1	6	Nov 68	1	2	1	2	11
Network summary		1,451	457	0	1		6	73	6	8	23

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

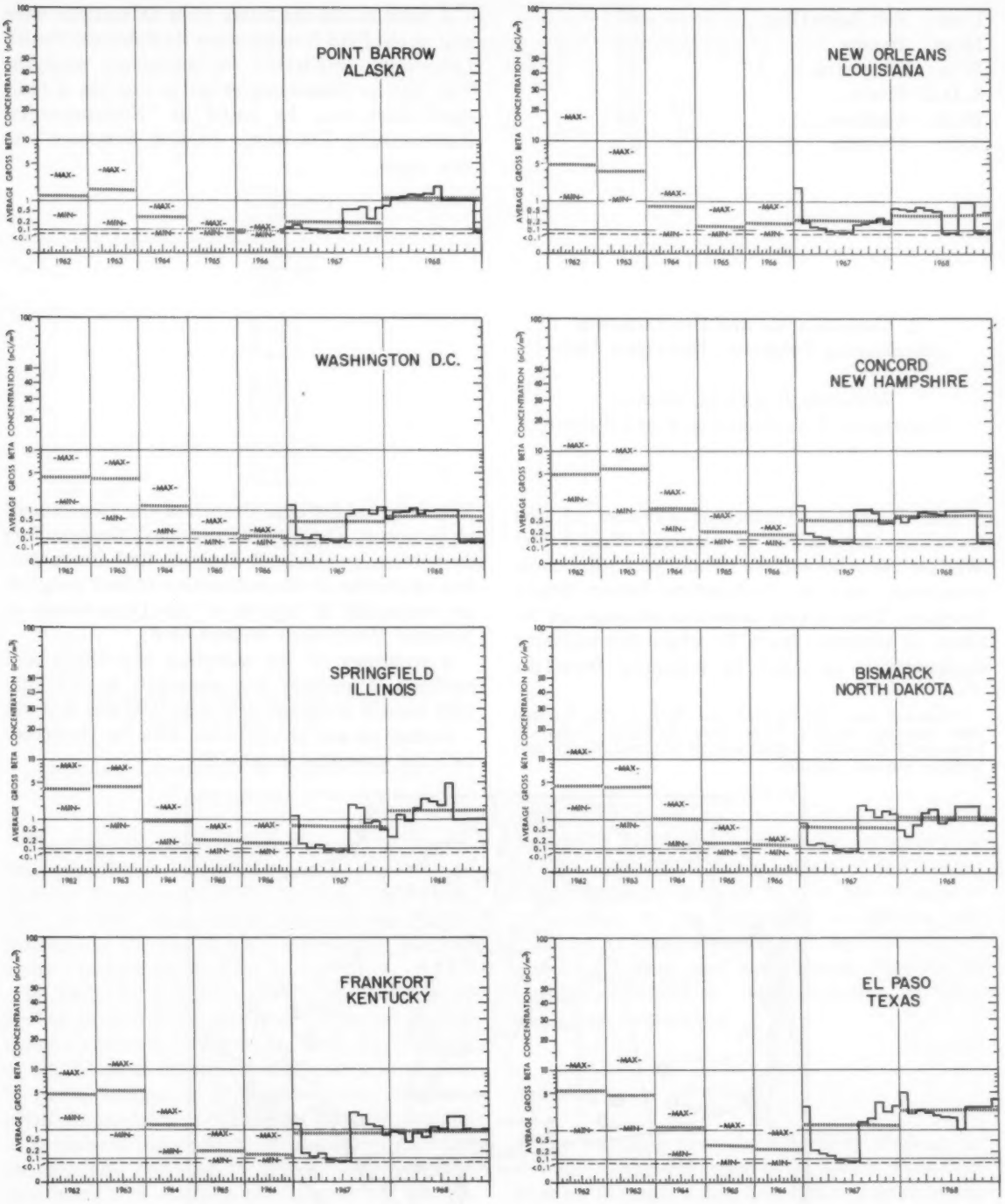

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1962–December 1968

Utah:	Salt Lake City	167
Mont:	Helena	179
Wyo:	Cheyenne	171
S. Dak:	Pierre	65
Wash:	Spokane	44
Ariz:	Phoenix	41

A total of 215 air filters from 28 stations were sent to the PHS Northeastern Radiological Health Laboratory (NERHL) for laboratory analysis. The data for these samples and evaluation of their significance may be found in "Environmental Radioactivity Following Project Schooner" in this issue.

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2. Canadian Air and Precipitation Monitoring Program,[1] December 1968

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the July 1968 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for December 1968 are presented in table 2.

[1] Prepared from information and data in the January 1969 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

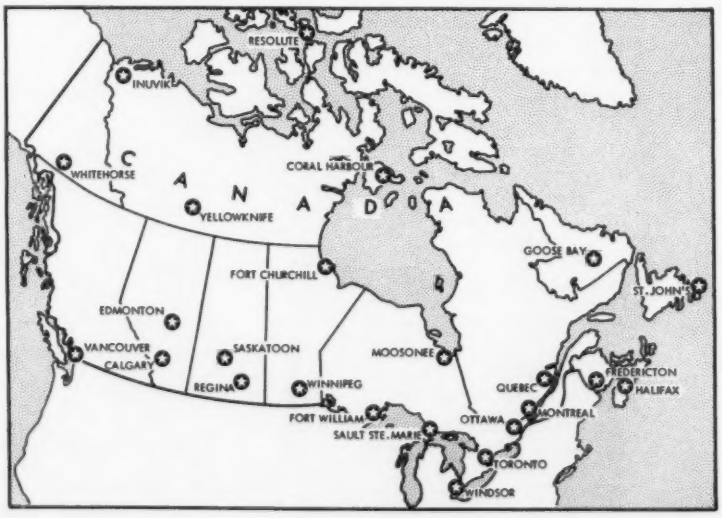

Figure 3. Canadian air and precipitation sampling stations

Table 2. Canadian gross beta radioactivity in surface air and precipitation, December 1968

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	31	0.3	0.0	0.1	NA	NA
Coral Harbour	31	.1	.0	.1		
Edmonton	31	.1	.0	.1		
Ft. Churchill	30	.1	.0	.1		
Ft. William	31	1.5	.0	.1		
Fredericton	31	.5	.0	.1		
Goose Bay	28	.1	.0	.0		
Halifax	31	.6	.0	.1		
Inuvik	31	.1	.0	.1		
Montreal	31	1.1	.0	.1		
Moosonee	30	.1	.0	.0		
Ottawa	30	2.0	.0	.1		
Quebec	31	.9	.0	.1		
Regina	31	.3	.0	.1		
Resolute	25	.1	.0	.1		
St. John's, Nfld	31	.5	.0	.0		
Saskatoon	31	.4	.0	.1		
Saulte Ste Marie	16	.1	.0	.1		
Toronto	30	.9	.0	.1		
Vancouver	29	.3	.0	.0		
Whitehorse	31	.1	.0	.0		
Windsor	31	.4	.0	.1		
Winnipeg	31	.2	.0	.1		
Yellowknife	31	.1	.0	.1		
Network summary	714	2.0	0.0	0.1		

NA, not available.

3. Mexican Air Monitoring Program July–August 1968

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

Figure 4. Mexican air sampling stations

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of 5 samples per month were needed to get a reliable average radioactivity at each station (7).

The maximum, minimum, and average beta radioactivity in surface air during July and August 1968 are presented in tables 3 and 4, respectively.

Table 3. Mexican gross beta radioactivity of airborne particulates, July 1968

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	11	0.1	0.1	0.1
Chihuahua	9	.2	.1	.1
Ciudad Juárez	4	.3	.1	.2
Ensenada	8	.3	.1	.2
Guadalajara	NS			
Guaymas	NS			
La Paz	2	.3	.1	.2
Matamoros	NS			
Mazatlán	8	.5	.2	.3
Mérida	NS			
México, D.F.	1	.2	.2	.2
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	4	.4	.3	.3
Torreón	8	.4	.2	.3
Veracruz	3	.3	.3	.3

NS, no sample, station temporarily shutdown.

Table 4. Mexican gross beta radioactivity of airborne particulates, August 1968

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	NS			
Chihuahua	4	0.3	0.2	0.2
Ciudad Juárez	3	.4	.3	.3
Ensenada	8	.6	.2	.5
Guadalajara	NS			
Guaymas	NS			
La Paz	5	.5	.2	.3
Matamoros	NS			
Mazatlán	NS			
Mérida	13	.5	.2	.4
México, D.F.	NS			
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	8	.2	.1	.2
Torreón	10	.1	.1	.1
Veracruz	15	.5	.1	.1

NS, no sample, station temporarily shutdown.

4. Pan American Air Sampling Program December 1968

Pan American Health Organization and
U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the January 1968 *Radiological Health Data and Reports*. The December 1968 air monitoring results from the participating countries are given in table 5.

Figure 5. Pan American Air Sampling Program stations

Table 5. Summary of gross beta radioactivity in Pan American surface air, December 1968

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	17	0.43	0.08	0.24
Bolivia: La Paz	6	.75	.17	.27
Chile: Santiago	31	.40	.05	.20
Colombia: Bogota	11	.06	.01	.02
Ecuador: Guayaquil	21	.61	.17	.34
Guyana: Georgetown	15	.55	.01	.13
Jamaica: Kingston	19	.15	.02	.05
Peru: Lima	NS			
Venezuela: Caracas	9	.41	.03	.05
West Indies: Trinidad	20	.17	.01	.03
Pan American summary	149	0.75	0.01	0.16

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
NS, no samples received.

REFERENCES

(1) PUBLIC HEALTH SERVICE. Environmental Radiation Surveillance Report. Bureau of Radiological Health, Office of Criteria and Standards, Rockville, Md. 20852 (Distribution by official request).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual Report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(3) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(4) MAR, P. G. Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(5) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(6) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(7) VASQUEZ, M., and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la República Mexicana, 1963–1965. Comisión Nacional de Energía Nuclear, Dirección General de Sequridad Radiológica (1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Radioactivity Following Project Schooner

Bureau of Radiological Health[1]
U.S. Public Health Service

On December 8, 1968, at 0800 P.s.t., the Atomic Energy Commission executed a nuclear cratering experiment as part of its Plowshare program to develop peaceful uses for nuclear explosives. The experiment, called Project Schooner, consisted of the detonation of a 35 kiloton (equivalent to 35,000 tons of TNT) minimum fission nuclear explosive at a depth of 350 feet underground at the Nevada Test Site. The purpose of this test was to provide information about cratering effects in hard rock. The detonation resulted in a crater about 800 feet wide and 250 feet deep and a release of radioactive debris into the atmosphere.

This report presents and evaluates the findings of the Public Health Service's two major nationwide environmental radioactivity surveillance networks following this event.

The Radiation Alert Network (RAN) consists of 73 stations located throughout the United States (figure 1) and provides an alert to increases in airborne radioactivity by the daily collection of 24-hour air samples and subsequent field estimation of gross beta radioactivity. Samples having unusual amounts of radioactivity are analyzed further at one of the Bureau of Radiological Health (BRH) regional laboratories. RAN results are published monthly in *Radiological Health Data and Reports*. A more complete description of RAN operational procedures was presented in the March 1968 issue.

In anticipation of the Schooner event, 31 of the 73 RAN stations were requested to modify their routine sampling procedure and collect 12-hour air samples during the period, Monday, December 9 through Friday, December 13. These stations were selected on the basis of predicted trajectories for the Schooner debris and are shown in figure 1. The operators of these stations were asked to perform a field estimate on these special samples at either 5 or 12 hours after collection (depending on whether the sample was collected in the morning or at night, respectively), and then to send the filters to RAN headquarters in Rockville, Md. Field estimates greater than 15 pCi/m^3 were to be reported to RAN headquarters by telephone.

The Pasteurized Milk Network (PMN) consists of 63 stations located throughout the United States (figure 2). Pasteurized milk samples are collected weekly from major milksheds and analyzed for radioactivity at the three BRH regional laboratories. The results are reported monthly in *Radiological Health Data and Reports*. A more complete description of the PMN may be found in the January 1968 issue.

In contrast to RAN procedures, increased sampling frequency is not initiated for the PMN prior to an event. Instead, preliminary post-shot RAN telephone alert reports are used as a guide to adjust PMN sampling frequency. Following the detonation of Schooner and in conjunction with preliminary telephone reports from various RAN stations, 12 of the 63 PMN stations

[1] Special report prepared by the staff of the Radiological Surveillance Branch, Division of Environmental Radiation.

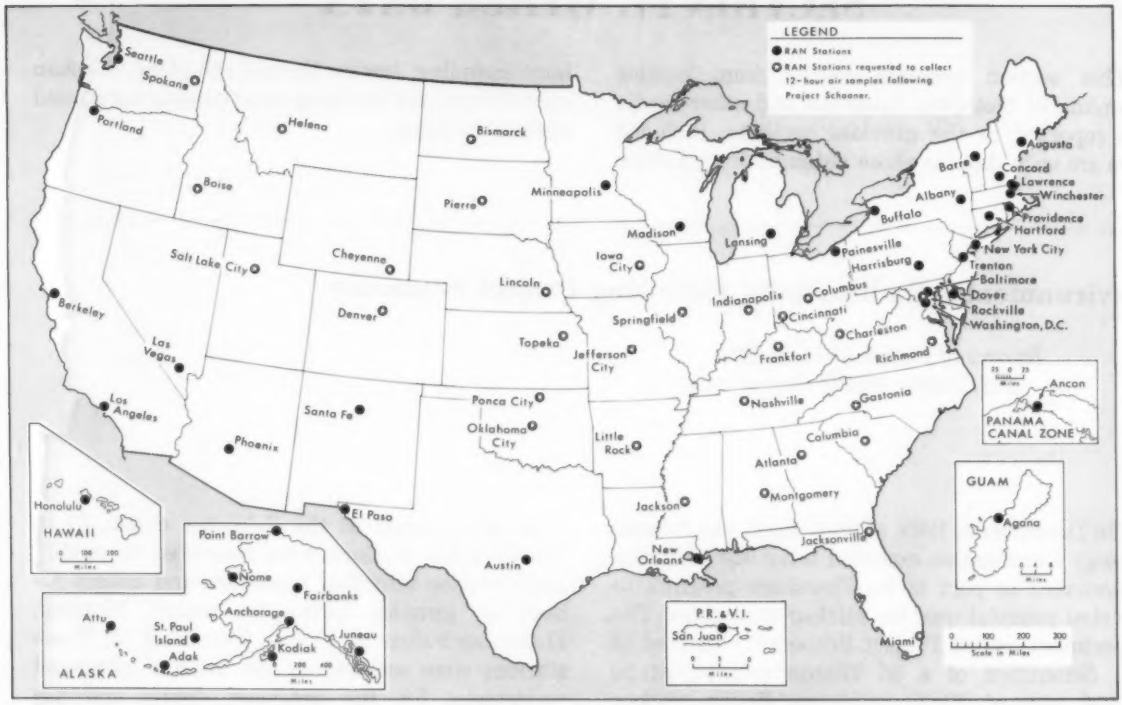

Figure 1. Radiation Alert Network sampling stations

were requested to increase sampling frequency to twice per week. This frequency was maintained at these stations for 3 weeks following the event. The PMN stations which were requested to increase sampling frequency are shown in figure 2.

Results

The highest reported field estimate of airborne radioactivity following the Schooner event was 457 pCi/m³ for an air sample collected at Boise, Idaho from 2100 hours on December 9 to 0900 hours on December 10. Significantly elevated levels of airborne radioactivity were also observed at a number of other RAN stations during the week of December 9 to 13. Those stations with elevated field estimates are shown in table 1.

A total of 215 air filters from 28 stations were sent to the BRH Northeastern Radiological

Table 1. Field estimates of gross beta radioactivity (pCi/m³) for the week of December 9–13 for those RAN stations with significantly elevated levels

Station	Monday (12/9)		Tuesday (12/10)		Wednesday (12/11)		Thursday (12/12)		Friday (12/13)	
	AM[a]	PM[a]	AM	PM	AM	PM	AM	PM	AM	PM
Boise, Idaho	2	408	457	97	24	6	1	1	1	1
Denver, Colo.	8	4	160	173	43	10	4	1	1	[b]NR
Salt Lake City, Utah	3	[c]CS	167	17	9	0	0	0	0	0
Cheyenne, Wyo.	4	4	171	35	13	4	4	3	2	NR
Helena, Mont.	4	4	179	149	84	4	4	1	2	CS
Spokane, Wash.	0	CS	4	44	1	1	1	0	1	0
Pierre, S. Dak.	NR	4	7	44	65	26	8	3	2	NR
Phoenix, Ariz.	6	CS	14	CS	17	CS	41	CS	27	CS

[a] Unless otherwise indicated, these are 12-hour samples. AM samples generally represent collection from 2100 to 0900 and PM samples generally represent collection from 0900 to 2100.
[b] Not reported; an air sample was collected but no field estimate was made.
[c] Continuous sample.

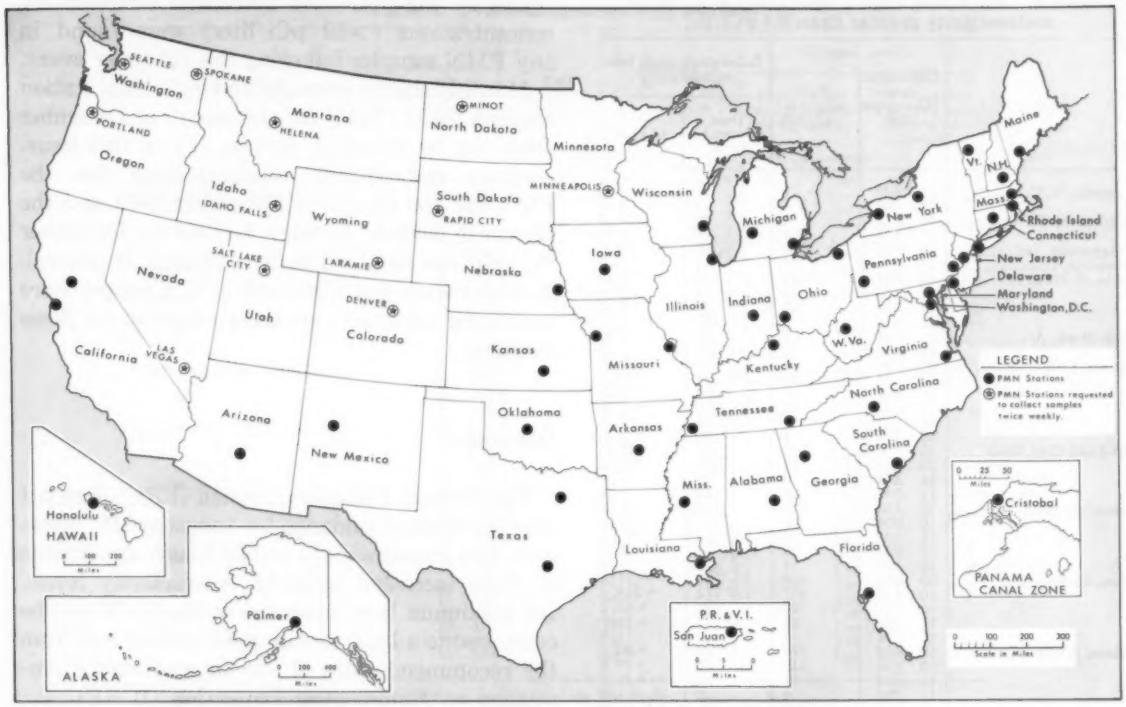

Figure 2. Pasteurized Milk Network sampling stations

Health Laboratory (NERHL) for more complete analysis. Each filter was counted for gross beta radioactivity immediately upon receipt at the laboratory. Table 2 gives the results for those samples which had a gross beta radioactivity greater than 0.5 pCi/m³ (selected as a cutoff value for gamma analysis) at the time of counting. Forty-one air filters were over 0.5 pCi/m³ and 28 of these were selected for gamma radioanalysis.

A total of 34 air filters were analyzed by gamma-ray spectroscopy including several filters chosen to provide background information. The results of these analyses are given in table 3. Each filter was counted for 50 minutes with a gamma-ray spectrometer incorporating a NaI (T1) crystal, and several were also counted for approximately 1,000 minutes with a germanium–lithium (GeLi) high resolution solid state spectrometer. The period between detonation and analysis for these samples varied from 6 to 18 days. Tungsten-187 was the predominant radionuclide identifiable in the gamma spectra of the samples analyzed at D+6 days. Quantitative data for this radionuclide were obtained from the solid state spectrometer output by hand spectrum stripping of the 0.686 MeV-peak (3.8 percent counting efficiency). Other radionuclides identified qualitatively are:

Beryllium-7	Iodine-132
Potassium-40	Cesium-134
Niobium-95	Cesium-137
Zirconium-95	Barium-140
Ruthenium-103	Lanthanum-140
Ruthenium-106	Cerium-141
Iodine-131	Tungsten-181

As the time between detonation and analysis increased, only these latter radionuclides were identifiable from the gamma spectra.

No detectable tungsten-187 concentrations (>50 pCi/liter) were found in any PMN samples following the Schooner event. Only one PMN

Table 2. Air filters with a laboratory gross beta radioactivity greater than 0.5 pCi/m³

Station	Collection date (December 1968)	Field estimate (pCi/m³)	Laboratory gross beta radioactivity	
			Date (December 1968)	pCi/m³
Gastonia, N. C.	13 AM[a]	7	20	0.6
	13 PM[a]	[c] NR	19	[b] .6
Charleston, W. Va.	12 PM	1	20	.8
	13 AM	2	20	.7
Indianapolis, Ind.	13 PM	NR	20	[b] 1.3
Columbus, Ohio	13 AM	1	19	.7
Pierre, S. Dak.	10 PM	44	14	[b] 10.6
	11 AM	65	14	[b] 9.5
	11 PM	26	20	[b] 7.1
	12 AM	8	20	1.1
Little Rock, Ark.	11 PM	3	19	[b] .9
	13 AM	2	19	.7
Denver, Colo.	09 PM	4	14	[b] .6
	10 AM	160	14	[b] 3.8
	10 PM	173	14	[b] 76.7
	11 AM	43	14	[b] 17.8
	11 PM	10	20	[b] 3.6
	12 AM	4	20	1.2
Salt Lake City, Utah	10 AM[d]	167	20	[b] 37.6
	10 PM	17	20	[b] 9.8
	11 AM	9	14	[b] 7.8
	11 PM	0	19	1.1
Cheyenne, Wyo.	10 AM	171	19	[b] 80.3
	10 PM	35	19	[b] 23.3
	11 AM	13	19	[b] 4.9
	11 PM	4	20	1.9
	12 AM	4	20	1.6
Boise, Idaho	09 PM	408	14	[b] 191.8
	10 AM	457	14	[b] 315.2
	10 PM	97	20	[b] 65.4
	11 AM	24	20	[b] 12.7
	11 PM	6	20	1.0
Helena, Mont.	10 AM	179	14	[b] 69.4
	10 PM	149	20	[b] 76.6
	11 AM	84	20	[b] 41.7
	11 PM	4	20	.8
	12 AM	4	20	.7
Phoenix, Ariz.	12 AM[d]	41	26	[b] 13.3
	13 AM[d]	27	26	[b] 5.5
Spokane, Wash.	10 AM[d]	4	19	[b] 1.5
	10 PM	44	19	[b] 32.7

[a] Unless otherwise indicated, these are 12-hour samples. AM samples generally represent collection from 2100 to 0900 and PM samples represent collection from 0900 to 2100.
[b] Indicates samples which were selected for gamma analysis.
[c] Not reported; an air sample was collected but no field estimate was made.
[d] 24-hour samples.

sample was found to contain a detectable concentration (>10 pCi/liter) of iodine-131 during the month of December. This sample was collected from Portland, Maine on December 30, which had 13 pCi/liter of iodine-131. This value is within the statistical variation for detection of iodine-131 in milk.

There were three PMN stations which showed detectable concentrations (>10 pCi/liter) of iodine-131 or barium-140 following the Schooner event. They were Portland, Maine, which had 13 pCi/liter of iodine-131 on December 30, and Sacramento, Calif., and Omaha, Nebr., which had 16 and 18 pCi/liter of barium-140, respectively, on December 13. Significantly increased air concentrations were not observed in these States by the RAN. No detectable tungsten-187 concentrations (>50 pCi/liter) were found in any PMN samples following the Schooner event.

Monthly station averages and individual station maxima for the RAN for the month of December 1968 can be found in Section III of this issue. Average radionuclide concentrations for the PMN for the month of December 1968 and the 12-month period, January 1, 1968 to December 31, 1968, can be found under Section I. In general, station values not discussed in this report were within the variations normally observed for these locations.

Discussion

The Federal Radiation Council (FRC) does not provide explicit guidance for tungsten-187. However, as a measure of the public health significance of these increased airborne radioactivity levels, the maximum level observed in the RAN can be compared to a limit for tungsten-187 derived from the recommendations of the International Commission on Radiological Protection (ICRP).

A derived limit for tungsten-187 in air was calculated to be 10,000 pCi/m³; the most restrictive 168-hour occupational MPC for radiation workers was reduced using a factor of 1/10, in accordance with recommendations of FRC and ICRP, in order to arrive at a limit applicable to continuous inhalation over a 50-year period by an individual in the general population. The derived limit corresponds to a dose rate which would not exceed 0.5 rem/year, the FRC Radiation Protection Guide (RPG) for individuals in the general population.

The highest tungsten-187 concentration obtained from RAN samples was 917 pCi/m³ (corrected for decay to the end of sample collection) for a sample collected at Boise, Idaho on December 10. Had this concentration persisted indefinitely, the resultant dose would have been less than 10 percent of the RPG for individuals. Because the air concentrations remained elevated for only a few days at most, the resultant dose would actually be several orders of magnitude lower, or on the order of one-tenth of 1 percent of the RPG. Other locations with lower concentrations of tungsten in air would give correspondingly lower dose estimates. Based on these estimates, it

Table 3. Gamma spectroscopy results

Station	Collection date (December 1968)	Field estimate (pCi/m³)	Laboratory gross beta radioactivity (pCi/m³)	Gamma results	
				Fresh fission products and/or tungsten	^{187}W-quantitative (pCi/m³) (at end of collection)
Gastonia, N.C.	13 PM	[a] NR	.6	No	
Indianapolis, Ind.	13 PM	NR	1.3	[b] Yes	
Pierre, S.Dak.	10 AM	7	.1	No	
	10 PM	44	10.6	Yes	48
	11 AM	65	9.5	Yes	19
	11 PM	26	7.1	Yes	
Austin, Tex.	10 AM	8	.2	Yes	
Little Rock, Ark.	11 PM	3	.9	[b] Yes	
Denver, Colo.	09 PM	4	.6	No	
	10 AM	160	[c] 3.8	Yes	120
	10 PM	173	76.7	Yes	175
	11 AM	43	17.8	Yes	27
	11 PM	10	3.6	Yes	
Salt Lake City, Utah	09 AM	3	.3	No	
	10 AM	167	37.6	Yes	
	10 PM	17	9.8	Yes	
	11 AM	9	7.8	Yes	36
Cheyenne, Wyo.	09 AM	4	.3	No	
	10 AM	171	80.3	Yes	
	10 PM	35	23.3	Yes	
	11 AM	13	4.9	Yes	
Boise, Idaho	09 AM	2	.1	No	
	09 PM	408	191.8	Yes	807
	10 AM	457	315.2	Yes	917
	10 PM	97	65.4	Yes	
	11 AM	24	12.7	Yes	
Helena, Mont.	09 PM	4	.1	No	
	10 AM	179	69.4	Yes	166
	10 PM	149	76.6	Yes	
	11 AM	84	41.7	Yes	
Phonex, Ariz.	12 AM	41	13.3	Yes	
	13 AM	27	5.5	Yes	
Spokane, Wash.	10 AM	4	1.5	Yes	
	10 PM	44	32.7	Yes	

[a] Not reported; an air sample collected but no field estimate was made.
[b] Tentative identification-based primarily on the presence of the x-ray peak.
[c] Questionable value.

is concluded that no public health problem resulted from the Schooner event.

Summary

Significantly elevated levels of airborne radioactivity were observed at several RAN stations following the Schooner event; some of the maximum values were the highest that have been observed at these locations since 1962. These levels were of short duration, with all affected locations returning to normal background activities within a few days. The composition of the radioactivity in the samples was different from that observed in the early 1960's. The predominant radionuclide was tungsten-187, which decays rapidly with a half-life of 24 hours. Only small amounts of iodine-131 and other fresh fission products were observed in RAN air samples following Schooner. No tungsten-187 was detected in samples collected as a part of the PMN and only one milk sample had a detectable concentration of iodine-131. Based on the data obtained from these two networks, it is concluded that no public health hazard resulted from Project Schooner.

Strontium-90 in Human Bone, January-March 1968[1]

Bureau of Radiological Health
Public Health Service

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older age groups have shown their bone strontium-90 content to be low and age-independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority

[1] Period during which death or surgical procedure occurred.

Table 1. Strontium-90 in human bone, January-March 1968

Bone region and State		Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration (pCi/kg bone)	Calcium concentration (g/kg bone)	$^{90}Sr/Ca$ (pCi/g)
Northeast:	Mass.	V	00	M	079.4 ±[c] 14.0	35.6	2.23
	N. Y.	V	00	M	102.0 ± 16.0	33.1	3.08
	Mass.	V	03	M	104.0 ± 8.0	35.1	2.96
		V	05	M	107.0 ± 10.0	23.8	4.49
		V	06	M	101.0 ± 9.5	34.6	2.91
	N. J.	V	06	F	288.0 ± 20.0	90.4	3.18
	Pa.	V	07	M	53.5 ± 8.1	20.3	2.63
	Mass.	V	08	M	47.6 ± 8.0	31.7	1.50
		V	08	M	172.0 ± 12.0	36.7	4.68
	N. Y.	V	08	F	58.6 ± 6.3	34.2	1.71
	Mass.	V	09	M	110.0 ± 11.0	30.1	3.65
		V	10	M	76.8 ± 6.6	31.3	2.45
		V	12	M	79.9 ± 7.8	36.5	2.18
	Vt.	V	15	M	141.0 ± 12.0	46.7	3.01
	N. Y.	V	15	M	75.3 ± 8.7	30.6	2.46
	Mass.	V	16	F	164.0 ± 14.0	52.0	3.15
	N. Y.	V	17	M	141.0 ± 12.0	51.1	2.75
		V	17	M	185.0 ± 47.0	66.3	2.79
		V	17	M	119.0 ± 12.0	50.5	2.35
		V	19	M	46.5 ± 6.2	35.9	1.29
	Mass.	V	20	M	99.7 ± 8.3	44.0	2.26
	N. Y.	V	20	M	61.5 ± 6.9	29.6	2.07
		V	25	M	121.0 ± 10.0	52.8	2.29
Southeast:	S. C.	V	00	M	152.0 ± 20.0	29.4	5.17
		V	00	M	92.8 ± 12.0	19.7	4.71
		V	01	F	77.0 ± 17.0	26.4	2.91
		V	01	F	161.0 ± 18.0	29.4	5.47
	N. C.	V	02	M	143.0 ± 15.0	27.0	5.29
	S. C.	V	02	M	100.0 ± 10.0	24.4	4.09
		V	02	F	75.4 ± 9.7	26.2	2.87
	Md.	V	07	F	76.7 ± 8.7	28.6	2.68
		V	07	M	85.9 ± 11.0	30.7	2.79
	N. C.	V	07	F	114.0 ± 13.0	24.7	4.61
	Ga.	V	08	F	144.0 ± 17.0	38.9	3.70
	Ala.	V	11	M	60.8 ± 8.5	30.3	2.00
	S. C.	V	12	F	80.4 ± 8.9	27.2	2.95
	Md.	V	14	M	124.0 ± 13.0	47.4	2.61
	N. C.	V	14	F	68.4 ± 8.9	23.4	2.92
	Va.	V	14	M	65.3 ± 8.2	23.7	2.75
	Md.	V	15	M	180.0 ± 14.0	63.2	2.84
	N. C.	V	15	F	144.0 ± 10.0	43.0	3.34
	Md.	V	16	M	130.0 ± 13.0	46.9	2.77
		V	17	M	150.0 ± 13.0	55.7	2.69
		V	17	F	93.9 ± 8.6	46.8	2.00
		V	17	M	161.0 ± 14.0	61.4	2.62
		V	17	M	163.0 ± 15.0	55.5	2.93
	N. C.	V	17	F	96.9 ± 8.3	36.3	2.66
	Md.	V	18	M	108.0 ± 11.0	47.0	2.29
		V	18	M	183.0 ± 14.0	55.0	3.32
	N. C.	V	18	F	92.0 ± 13.0	34.5	2.66
		V	18	M	280.0 ± 16.0	51.4	5.44
	Md.	V	19	M	96.6 ± 11.0	53.9	1.79
		V	19	M	122.0 ± 13.0	63.4	1.92
		V	19	M	62.1 ± 9.4	51.1	1.21
		V	20	M	85.2 ± 10.0	54.1	1.57
		V	20	M	111.0 ± 9.5	45.9	2.41
		V	20	M	103.0 ± 7.8	44.1	2.33
		V	21	M	68.5 ± 8.4	48.4	1.41
	Ga.	V	21	M	261.0 ± 18.0	56.6	4.61
	Md.	V	22	M	106.0 ± 10.0	61.7	1.71
	D. C.	V	22	M	99.7 ± 9.6	58.0	1.71
	Md.	V	22	M	104.0 ± 11.0	55.3	1.88
		V	22	M	110.0 ± 10.0	50.7	2.16
		V	22	M	104.0 ± 10.0	59.3	1.75
	S. C.	V	22	F	169.0 ± 17.0	58.3	2.89
	Md.	V	23	M	156.0 ± 9.6	50.3	3.10
		V	23	M	83.1 ± 10.0	49.0	1.69
	N. C.	V	23	F	227.0 ± 17.0	45.7	4.96
		V	23	M	87.0 ± 10.0	32.1	2.71
	S. C.	V	23	F	57.0 ± 8.7	48.9	1.16
	Md.	V	24	M	151.0 ± 15.0	78.2	1.93
		V	24	M	115.0 ± 13.0	69.2	1.66
		V	24	M	82.7 ± 9.0	44.2	1.87
	S. C.	V	25	F	74.3 ± 7.1	40.7	1.82
Central:	Wisc.	V	00	F	109.0 ± 15.0	40.1	2.71
		V	00	F	54.0 ± 12.0	27.9	1.93
		V	00	F	92.5 ± 16.0	40.5	2.28
	Ohio	V	01	F	98.4 ± 15.0	31.0	3.17
	Wisc.	V	01	M	52.3 ± 10.0	17.8	2.93
		V	01	M	52.1 ± 17.0	34.4	1.51
	Ohio	V	01	M	96.2 ± 13.0	25.3	3.80
	Wisc.	V	05	M	50.2 ± 7.5	25.9	1.93
		V	06	M	128.0 ± 12.0	28.0	4.57
		V	07	M	64.3 ± 6.8	34.8	1.84
	Ohio	V	07	M	191.0 ± 14.0	50.7	3.76
	Iowa	V	10	F	58.7 ± 7.2	33.0	1.77
	Wisc.	V	15	M	162.0 ± 12.0	53.2	3.04
	Ohio	V	17	F	127.0 ± 11.0	50.6	2.50

See footnotes at end of table.

Table 1. Strontium-90 in human bone, January–March 1968—Continued

Bone region and State		Bone type [a]	Age [b] (years)	Sex	Strontium-90 concentration (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Central:	Ohio	V	17	M	164.0 ± 13.0	73.3	2.23
	Minn	V	20	M	70.7 ± 9.9	44.0	1.60
	Ohio	V	20	M	90.4 ± 8.7	58.6	1.54
Delta:	Tenn	V	11	M	76.2 ± 6.9	35.0	2.17
	La	V, R	14	M	68.5 ± 9.1	38.0	1.80
		V, R	18	M	95.2 ± 12.0	67.8	1.40
		V, R	22	M	151.0 ± 14.0	64.5	2.34
	Tenn	V	25	F	68.0 ± 8.2	41.6	1.63
Northwest:	Ore	V	04	M	71.3 ± 6.6	29.5	2.41
		V	10	F	65.5 ± 6.6	38.0	1.72
		V	12	M	101.0 ± 11.0	41.6	2.42
	Wash	V	13	F	94.4 ± 9.2	36.3	2.60
	Ore	V	15	M	109.0 ± 9.4	39.1	2.78
		V	15	F	126.0 ± 9.8	55.1	2.28
		V	16	M	114.0 ± 10.0	47.9	2.37
		V	16	F	69.8 ± 6.9	38.6	1.80
		V	17	M	84.8 ± 10.0	51.9	1.63
		V	17	M	123.0 ± 13.0	48.7	2.52
	Alaska	R	18	M	866.0 ± 78.0	29.0	6.71
	Ore	V	19	M	86.0 ± 9.5	50.0	1.72
		V	19	F	83.8 ± 8.1	50.8	1.64
		V	22	M	65.1 ± 10.0	50.1	1.29
		V	22	M	63.3 ± 7.4	54.8	1.15
	Alaska	R	23	M	973.0 ± 70.0	45.0	6.71
		V	24	M	63.0 ± 10.0	55.5	1.13
Southwest:	Tex	V	08	F	59.4 ± 10.0	29.9	1.98
	Colo	V, R	10	M	130.0 ± 13.0	54.3	2.39
		V	11	M	46.8 ± 8.9	35.0	1.33
	Tex	V	13	M	112.0 ± 12.0	43.3	2.58
	Colo	V	15	M	71.1 ± 8.6	45.5	1.56
		V	16	F	92.3 ± 16.0	51.8	1.78
		V	18	M	76.4 ± 11.0	53.6	1.42
		V	18	M	125.0 ± 11.0	52.1	2.39
		V	18	M	110.0 ± 10.0	41.8	2.63
		V	19	M	78.5 ± 11.0	59.0	1.33
		V	21	F	51.7 ± 8.6	52.8	.97
	Calif	V	24	M	103.0 ± 11.0	52.3	1.96

[a] Type of bone: vertebrae, V; rib, R.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.

are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

Laboratory procedures

The bones are analyzed at Northeastern Radiological Health Laboratory of the Bureau of Radiological Health, at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium-90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated (*3*) from the yttrium-90 radioactivity. For the purpose of maintaining analytical reproducibility, blind duplicate analyses are performed on 10 to 20 percent of the samples. To further check and maintain analytical accuracy, synthetic "bone ash" samples (calcium phosphate spiked with strontium-90) are analyzed periodically and cross-check analyses are carried out quarterly with the Health and Safety Laboratory of the AEC, which performs similar analyses.

The analytical results for strontium-90 in individual bones from persons dying during the first quarter (January–March) of 1968 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium-90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–5*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1967	June 1968
April–June 1967	September 1968
July–September 1967	October 1968
October–December 1967	February 1969

Figure 1. Geographical regions for human bone sampling

REFERENCES

(*1*) RIVERA, J. Strontium-90 in human vertebrae, 1962–1963. Radiol Health Data 5:511–513 (October 1964).
(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Strontium-90 content of human bones, 1961–1963. Radiol Health Data 5:231–239 (May 1964).
(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples, chemical and radiochemical procedures, NERHL 64–1. Northeastern Radiological Health Laboratory, Winchester, Mass. (April 1964).
(*4*) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium-90 in human bone, 1962–1963. Radiol Health Data 5:620–628 (December 1964).
(*5*) HALLISEY, R. M. and M. A. WALL. Strontium-90 in human bone, 1964–1965. Radiol Health Data Rep 8:415–419 (August 1967).

Iodine-131 in Bovine Thyroid, October-December 1968

Bureau of Radiological Health
Public Health Service

The Bureau of Radiological Health (formerly the National Center for Radiological Health) established a bovine thyroid network in October 1964 (*1*). Specimens are collected by the Livestock Slaughter Inspection Division, U.S. Department of Agriculture, and are analyzed by gamma-ray

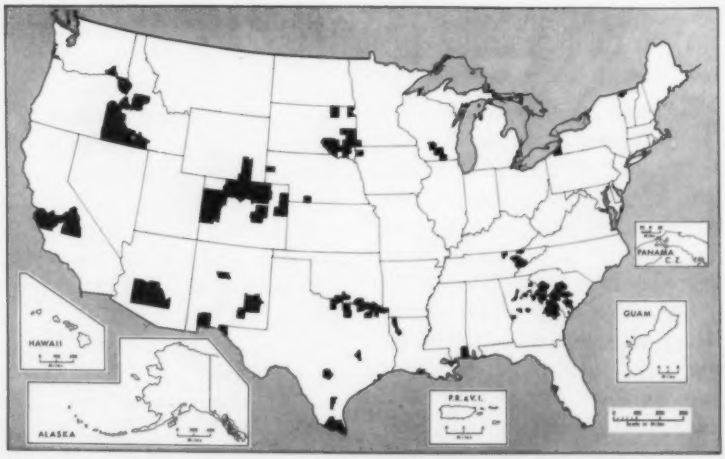

Figure 1. Counties sampled in bovine thyroid network, October–December 1968

Table 1. Iodine-131 in bovine thyroids, October–December 1968

State	Date of slaughter	County	Number of samples	pCi iodine-131/g thyroid [a]		
				Average or concentration	Minimum	Maximum
Arizona	10/4–11/27 [b]	Maricopa	11	4	0	31
	12/19	Pinal	1	0		
California	10/8–12/19 [b]	Fresno (3) [c]	20	0		
		Monterey (10)				
		San Benito (5)				
		Tulare (2)				
Colorado	10/15–12/10 [b]	Adams (4) [c]	5	0		
		Boulder (1)				
	11/1–12/19 [b]	Delta	16	2	0	6
	10/22–12/11 [b]	El Paso	5	0		
	10/10–10/28	Elbert	2	11	0	23
	10/15–12/10 [b]	Garfield	26	3	0	13
	10/24–12/18 [b]	Grand (1) [c]	11	0		
		Jackson (1)				
		Kit Carson (3)				
		Larimer (6)				
	10/4–12/4 [b]	Mesa	37	5	0	31
	11/7	Montrose	10	[d] 0		
	10/22	Morgan	1	0		
	11/29	Rio Blanco	10	1	0	7
	10/10	Routt	1	6		
	10/10–12/18 [b]	Weld	19	0	0	6
	10/29	Yuma	1	4		
Georgia	10/10–12/17 [b]	Bibb (7) [c]	27	[d] 0		
		Bulloch (2)				
		Burke (4)				
		Candler (3)				
		Clarke (6)				
		Columbia (3)				
		Emanuel (2)				
	10/10	Evans	2	5	2	7
	10/10–11/20	Franklin	2	[d] 0		
	10/3–11/27 [b]	Fulton	6	7	5	15
	10/16–12/17 [b]	Greene (5) [c]	6	[d] 0		
		Jenkins (1)				
	10/9–11/27 [b]	McDuffie	21	3	0	11
	10/16–12/17 [b]	Muscogee (5) [c]	14	0		
		Screven (8)				
		Upson (1)				
	10/3–11/6 [b]	Walton	7	4	0	10
	10/23–12/12 [b]	Warren	4	3	0	6
	10/23–12/17 [b]	Wilkes	8	0		
Idaho	10/4–12/9 [b]	Canyon (3) [c]	25	[d] 0		
		Owyhee (7)				
		Twin Falls (2)				
		Valley (6)				
		Washington (7)				
Iowa	10/14	Sioux	10	2	0	7
Louisiana	11/6–12/9	Bossier	2	0		
	10/14	Red River	1	9		
Minnesota	11/5	Rock	4	0		
Mississippi	10/1–10/16 [b]	George (2) [c]	4	[d] 0		
		(2)				
		Jackson	14	1	0	7
Nebraska	11/4–11/19 [b]	Red Willow (1) [c]	2	0		
		Scotts Bluff (1)				
New Mexico	11/4–12/2 [b]	Bernalillo (4) [c]	14	0		
		Chaves (10)				
	10/10	Luna	1	11		
New York	10/7–12/12 [b]	Chautauqua	59	0		
Oklahoma	10/22–12/6 [b]	Bryan (1) [c]	3	[d] 0		
		Carter (2)				
	11/5		1	6		
	10/23–12/5	Jefferson	2	0		
Oregon	12/25–12/3 [b]	Malheur (3) [c]	7	0		
		Wallowa (4)				
South Carolina	10/16–12/12 [b]	Abbeville (2) [c]	11	[d] 0		
		Aiken (2)				
		Barnwell (6)				
		Colleton (1)				
	11/6–12/17 [b]	Greenwood	4	2	0	9

See footnotes at end of table.

Table 1. Iodine-131 in bovine thyroids, October–December 1968—Continued

State	Date of slaughter	County	Number of samples	pCi iodine-131/g thyroid [a]		
				Average or concentration	Minimum	Maximum
South Carolina	10/16–12/17 [b]	Lexington (1) [c]	8	[d] 0		
		McCormick (2)				
		Orangeburg (3)				
		Richland (2)				
South Dakota	10/2–12/16 [b]	Aurora (10) [c]	91	[d] 0		
		Brookings (6)				
		Brown (3)				
		Brule (20)				
		Charles Mix (1)				
		Davidson (11)				
		Douglas (2)				
		Hutchinson (7)				
		Kingsbury (5)				
		Lake (1)				
		Mc Cook (11)				
		Minnehaha (3)				
		Moody (1)				
		Roberts (6)				
		Turner (4)				
		Yankton	4	6	2	9
Tennessee	10/8	Anderson	1	7		
	10/1–12/3 [b]	Blount	19	2	0	6
	10/1–12/3	Clairborne	2	[d] 0		
	10/1–12/3 [b]	Fentress (1)	12	[d] 0		
		Knox (11)				
	10/1–12/3 [b]	Seiver	4	4	0	17
Texas	11/25–12/17	Bexar (3) [c]	4	[d] 0		
		Bowie (1)				
	10/4	Brazos	1	8		
	12/4	Cameron	3	0		
	10/9	Clay	1	13		
	10/7	Cooke	1	6		
	10/28–11/26	Denton	2	[d] 0		
	10/15–12/6 [b]	El Paso	4	4	0	9
	10/9	Fannin	1	6		
	10/31–11/13	Hidalgo (2) [c]	3	[d] 0		
		Hopkins (1)				
	10/3		3	7	7	8
	10/10–12/12 [b]	Jim Wells (7) [c]	17	[d] 0		
		Lamar (1)				
		Red River (1)				
		Titus (1)				
		Willacy (7)				
Vermont	10/7–11/6 [b]	Franklin	30	[d] 0		
Washington	10/10–12/12 [b]	Walla Walla	15	[d] 0		
Wisconsin	10/9–11/22 [b]	Dane	14	1	0	8
	10/8	Rock	6	3	0	6
	11/8	Sauk	2	0		
Wyoming	10/17	Albany	1	0		

[a] All samples <1 pCi/g are reported as 0, since at these levels of radioactivity, the 2-standard deviation error is 1 pCi iodine-131/g thyroid.
[b] Samples were not collected on all dates during this period, but the interval includes several sampling dates.
[c] Numbers in parentheses represent the number of samples collected from that country during the interval indicated. These may have been collected over several dates or on only one date.
[d] The results for this period were for the most part not detectable. Some randomly scattered positive results were obtained; but these represented barely detectable amounts of iodine-131 in the bovine thyroid (2 to 5 pCi/g).
Dash indicates no data received.

spectroscopy for iodine-131 content at the Northeastern Radiological Health Laboratory, Winchester, Mass.

The network consists of collection areas (counties shaded in figure 1) located so as to cover, as nearly as possible, areas near major nuclear reactors, spent-fuel reprocessing plants, and nuclear test sites. Details of sampling and analyses have been published earlier (*1*).

The results for October through December 1968 appear in table 1 and are listed chronologically within each State. Moderate elevations in radioactivity were found in 15 States during this period. The two most active samples analyzed were collected in Maricopa County, Arizona and Mesa County, Colorado on October 4. They contained 31 pCi iodine-131/g thyroid.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1968	November 1968
July–September 1968	February 1969

REFERENCE

(*1*) BARATTA, E. J., E. R. WILLIAMS, and G. MURRAY. Iodine-131 in bovine thyroids, October–December 1964. Radiol Health Data 6:569–571 (October 1965).

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summary of the environmental radioactivity data follow for the Feed Materials Production Center.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Feed Materials Production Center[2] January–June 1968

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the AEC. The location as related to populated areas is shown in figure 1. Cincinnati and Hamilton, the larger nearby communities, are situated 20 and 10 miles from the center, respectively. Operations at this project deal with the processing of high-grade uranium ores and ore concentrates to produce metallic uranium and with fabricating the metal into fuel elements.

During the many involved reactions and processes that lead to the production of reactor fuels, various liquid and airborne wastes are generated. These wastes contain varying quantities of uranium. Various in-plant methods are used to curtail their release into the environment surrounding the plant. Almost complete removal of the materials is accomplished by using dust collectors and waste treatment processes. In order to determine what concentrations reach the area surrounding the project, an environmental survey program has been established which consists of water, soil, and air sampling of the environs and performing those analyses on the samples that are indicative of material released from the plants.

Onsite air samples are obtained from four permanent perimeter air sampling stations, located at the four corners of the production area as shown in figure 2. Samples from these perimeter stations are collected once each week and analyzed for uranium and total radioactivity. Offsite samples are collected by a mobile air sampling

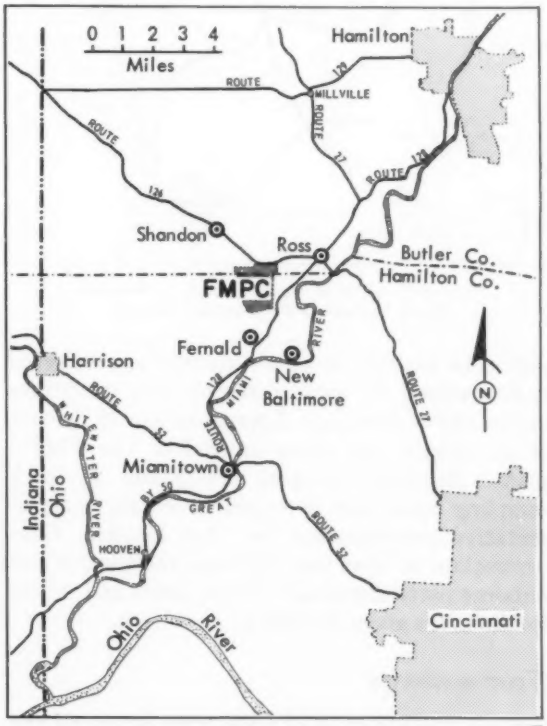

Figure 1. Area map of Feed Materials Production Center

[2] Summarized from "Feed Materials Production Center Environmental Monitoring Semiannual Report for the First Half of 1968" (NLCO-1023).

Table 1. Radioactivity levels of airborne particulates, Feed Materials Production Center, January–June 1968

Location	Number of samples	Uranium concentration (pCi/m^3)[a]			Total radioactivity (pCi/m^3)[b]		
		Maximum	Minimum	Average	Maximum	Minimum	Average
Onsite:							
Southwest	27	0.7	<0.1	0.2	1.3	<0.1	0.5
Northwest	27	.2	< .1	< .1	.4	< .1	.2
Northeast	27	.3	< .1	.1	.7	< .1	.4
Southeast	27	.3	< .1	.1	1.1	< .1	.4
All onsite samples	108	.7		.1	1.3		.4
Offsite:							
0–2 miles from FMPC	36	.5	< .1	.2	1.4	0.2	.7
2–4 miles from FMPC	38	.1	< .1	< .1	.9	< .1	.4
4–8 miles from FMPC	22	.2	< .1	< .1	.6	< .1	.3
8–12 miles from FMPC	16	< .1	< .1	< .1	.5	< .1	.2
All offsite samples	112	0.5		< .1	1.4		.4

[a] AEC radiation protection standard—2 pCi/m^3.
[b] AEC radiation protection standard—100 pCi/m^3.

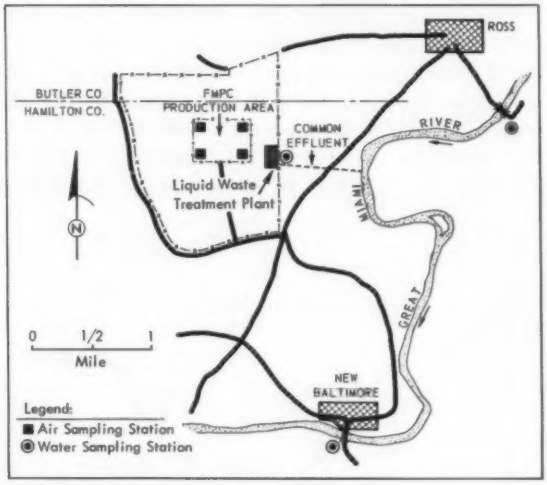

Figure 2. Air and water sampling stations Feed Materials Production Center

unit. The location at which samples are collected is determined by local meteorological conditions on the day of sampling. Approximately 20 percent of all samples are taken upwind of the FMPC plant. Replicate samples are taken at each sampling point and averaged to obtain a representative concentration for that location. Concentrations of uranium and total radioactivity of airborne particulates sampled at onsite and offsite locations are given in table 1.

Water monitoring

Each of the individual production plants on the project has collection sumps and treatment equipment to remove the uranium from the process waste water. The effluent from the plants are collected at a general sump for equalization and settling. The clear water from the sump is pumped to the river. The solid portion is pumped to a chemical waste pit for further settling. The flow, which is decanted to the clear well portion of the pit, is virtually free of solids and radioactivity. The effluent from the sump and clear well are combined with wastewater from the FMPC water treatment plant, sanitary sewage treatment plant, and storms weerage system and discharged via a common effluent outfall into the Great Miami River. A weir-type water sampler collects samples of the combined effluent stream, which are removed and analyzed daily. These results are utilized with measurements of river flow in calculating the radioactive contaminant concentrations added to the river. Weekly spot samples are also obtained upstream and downstream from the common FMPC effluent at locations shown in figure 2. The results of the FMPC water monitoring program for January–June 1968 are summarized in table 1.

Table 2. Radioactivity in the Great Miami River FMPC, January–June 1968

Location	Number of samples	Uranium concentration (pCi/liter)[a]			Total radioactivity (pCi/liter)[b]		
		High	Low	Average	High	Low	Average
Sewer outfall	182	<10	<10	<10	80	<10	20
Upstream from outfall	24	10	<10	6	80	<10	30
Downstream from outfall	31	30	<10	5	80	<10	30

[a] AEC radiation protection standard—20,000 pCi/liter.
[b] AEC radiation protection standard—3,000 pCi/liter.

Reported Nuclear Detonations, March 1969

The U.S. Atomic Energy Commission announced that the United States had recorded seismic signals originating from the Soviet underground nuclear test area in the Semipalatinsk region on March 7, 1969. The signals were equivalent to those of a nuclear test in the low-intermediate yield range (20–200 kilotons TNT equivalent).

Announcements were also made by the U.S. Atomic Energy Commission of two nuclear tests, one of low yield (less than 20 kilotons TNT equivalent) on March 20, 1969, and one of less than 100 kilotons TNT equivalent on March 21, 1969. Both were conducted underground by the Atomic Energy Commission at its Nevada Test Site.

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